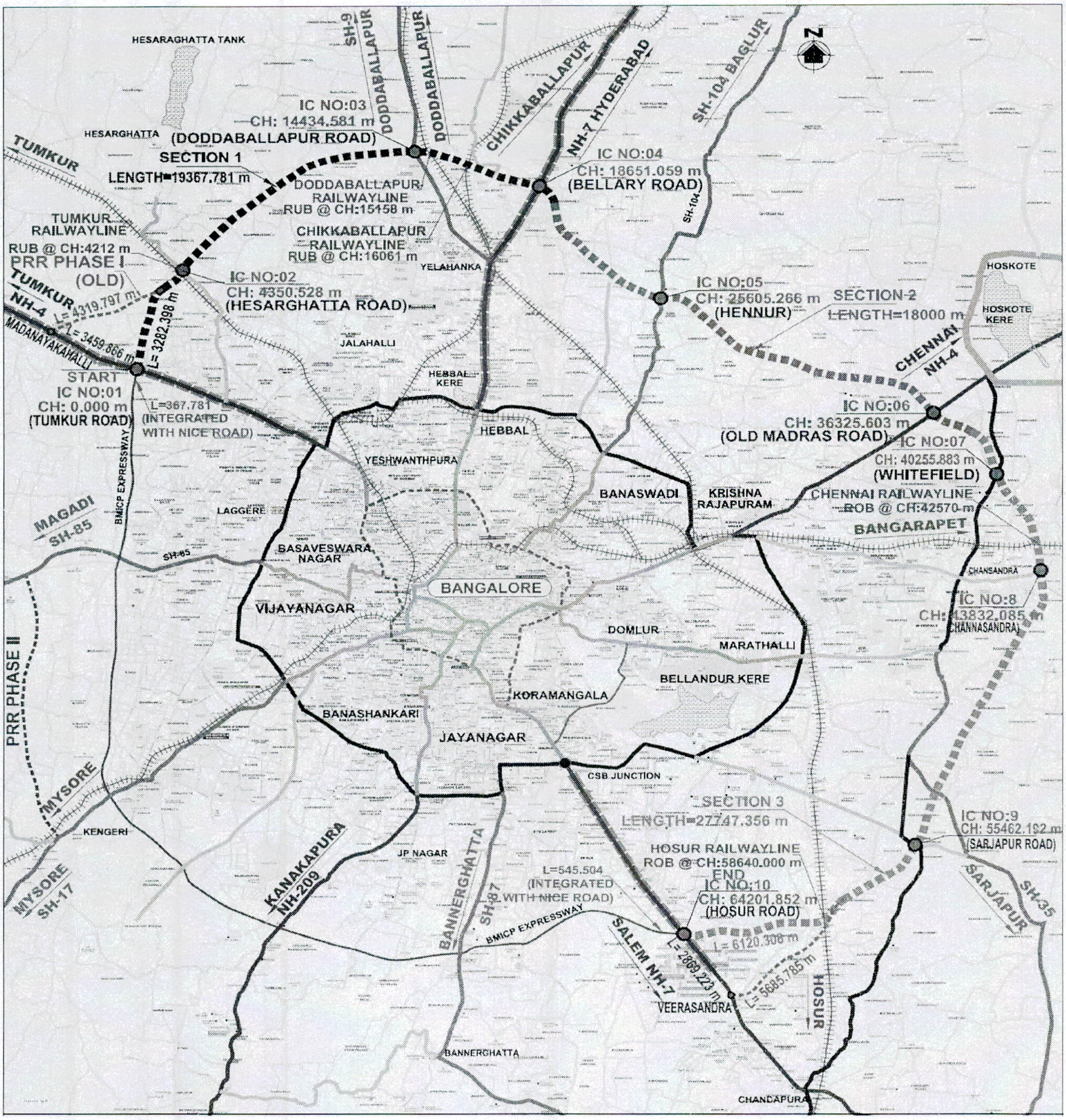
CONSTRUCTION OF EIGHT LANE PERIPHERAL RING ROAD TO BANGALORE CITY


HESARAGHATTA TANK
SH-9
DODDABALLAPUR
DODDABALLAPUR
CHIKKABALLAPUR
NH-7 HYDERABAD
SH-104 BAGLUR
N
IC NO:03
CH: 14434.581 m
(DODDABALLAPUR ROAD)
HESARGHATTA
TUMKUR
SECTION 1
LENGTH=19367.781 m
IC NO:04
CH: 18651.059 m
(BELLARY ROAD)
DODDABALLAPUR RAILWAYLINE RUB @ CH:15158 m
TUMKUR RAILWAYLINE RUB @ CH:4212 m
CHIKKABALLAPUR RAILWAYLINE RUB @ CH:16061 m
SH-104
PRR PHASE I (OLD)
YELAHANKA
HOSKOTE
TUMKUR NH-4
L=4319.797 m
IC NO:02
CH: 4350.528 m
(HESARGHATTA ROAD)
IC NO:05
CH: 25605.266 m
(HENNUR)
SECTION-2
LENGTH=18000 m
HOSKOTE KERE
MADANAYAKAHALLI
L=3459.666 m
L= 3282.398 m
JALAHALLI
CHENNAI NH-4
START
IC NO:01
CH: 0.000 m
(TUMKUR ROAD)
L=367.781 (INTEGRATED WITH NICE ROAD)
HEBBAL KERE
HEBBAL
IC NO:06
CH: 36325.603 m
(OLD MADRAS ROAD)
IC NO:07
CH: 40255.883 m
(WHITEFIELD)
YESHWANTHPURA
BANASWADI
KRISHNA RAJAPURAM
CHENNAI RAILWAYLINE ROB @ CH:42570 m
MAGADI SH-85
BMICP EXPRESSWAY
LAGGERE
BANGARAPET
SH-85
BASAVESWARA NAGAR
CHANSANDRA
BANGALORE
IC NO:8
CH: 43832.085 m
(CHANNASANDRA)
VIJAYANAGAR
DOMLUR
MARATHALLI
PRR PHASE II
BELLANDUR KERE
KORAMANGALA
BANASHANKARI
JAYANAGAR
MYSORE
CSB JUNCTION
SECTION 3
LENGTH=27747.356 m
KENGERI
IC NO:9
CH: 55462.192 m
(SARJAPUR ROAD)
HOSUR RAILWAYLINE ROB @ CH:58640.000 m
JP NAGAR
L=545.504 (INTEGRATED WITH NICE ROAD)
END
IC NO:10
CH: 64201.852 m
(HOSUR ROAD)
SARJAPUR
SH-35
MYSORE SH-17
KANAKAPURA NH-209
BANNERGHATTA
SH-87
BMICP EXPRESSWAY
SALEM NH-7
L=6120.308 m
L= 2809.223 m
L=5685.785 m
HOSUR
VEERASANDRA
BANNERGHATTA
CHANDAPURA

DRAFT DETAILED PROJECT REPORT

February 2020

GOVERNMENT OF KARNATAKA

Bangalore Development Authority
T. Chowdaiah Road, Kumara Park West,
Bengaluru- 560020.

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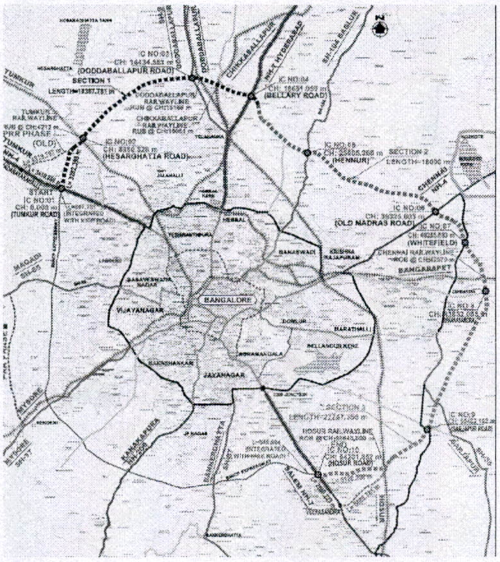
Executive Summary

Bangalore is the fifth largest city in India with an estimated population of more than 100 Lakhs spread over 821 Sq Km. The present day vehicle population is ~75 Lakh. The city has seen an increase of over 10.2% in last 10 years while the population is has increased by ~ 3.25% during the same period.



Bangalore has a radial road network with 6 primary National Highways and 6 State Highways converging / diverging from existing Outer Ring Road. The outer most road for Bangalore city at present is 65 Km long Outer Ring Road (ORR) constructed by Bangalore Development Authority. ORR was constructed as bypass to city taking away commercial vehicles and long distance personalised vehicles. Due to rapid ribbon development along ORR and beyond ORR lead to increase traffic on ORR and its interconnected roads. This has lead to traffic congestion at all major intersections and at midblock sections. Shift in International Airport from HAL to Devanahalli has changed the travel pattern in the city. At present, agencies like BDA and BBMP are implementing grade separators along ORR and at important junctions in the city. But this has not relieved traffic congestion between junctions.

The proposed Peripheral Ring Road (PRR) is planned beyond ORR at a distance of 17Km to 25Km from city centre. The proposed road is planned for following purposes:

- To take away commercial vehicles and long distance passenger cars from the city.
- Reduce traffic congestion on all existing radial roads leading to existing Outer Ring Road.
- Reduce traffic congestion on existing Outer Ring Road
- Create a new road network beyond ORR considering future needs for the city.

PRR is proposed with 100m Right of Way based on direction from the Government. The cross section comprises of divided eight lane main road separated with central median of 13m. Service roads, 11m in width in each direction are provided on either side of main road for local traffic. Main road is access controlled for trucks, buses, LCV and passenger cars. Service road and Main road are separated by built up drain. The space beyond service road is proposed with Footpath (2m), cycle track (2m), space for U/G cable and other utilities (3m) and an exclusive green corridor of 5m throughout the ROW.

There are 10 locations where PRR crosses major radial roads (National Highways and State highways). Junction treatment in the form of grade separator / interchanges is proposed at all junctions. PRR also crosses existing railway lines at 5 locations, where ROB / RUB are proposed.

Entry and exit to PRR is regulated. Traffic can enter and exit main road at major intersections after paying toll. Even though, the project is proposed to be taken up on Engineering Procurement & Construction basis or Hybrid Annuity Model, BDA may desire at a later date to levy toll from road users. Hence, toll plaza are proposed at entry and exit of all major intersections.

The project road is proposed with other facilities like cross drainage structures, longitudinal drains, median drains, and additional culverts across PRR for water supply lines, utility ducts and chambers. Road furniture like road signs, lane markings, crash barriers, road delineators, raised pavement markers, landscaping / arboriculture.

The project also aims to implementation of comprehensive state of the art Intelligent Transport System for the project road.

Land Acquisition required for construction of PRR project is in the progress.

The revised Detailed Project Report takes into consideration the fresh topography survey, revised cross section elements, suggestions / directions from Technical Advisory Committee / BDA / GOK, change in schedule of rates and approximate estimated project civil construction cost is Rs 4869 Crores. The project is expected to be completed in 36 months.

-----XXXXX-----

SECTION – 1

INTRODUCTION

1 INTRODUCTION

1.1 General

Bangalore is the fifth largest city in India with an estimated population of over 115 Lakhs (2011). The city limit which was around 425 Sq Km in 2007 has increased to over 800 Sq Km in a span of 6 years. However, the city road networks have not seen major improvements either in terms of enhancement of existing roadway capacity or creation of new road networks to reduce traffic congestion. The present day vehicle population in the city is around 85 Lakh with an average increase of vehicles at the rate of 10% per annum.

1.2 Existing Scenario

Bangalore has a radial road network around the city converging at existing outer ring road. There are 5 Primary road networks – NH-4 towards Pune on West, NH-7 towards Hyderabad on North, NH-4 towards Chennai on East, NH-7 towards Salem on South, NH-209 towards Dindigual towards South-West and NH-275 on South East. In addition there are 5 radial Secondary roads – SH-9 towards Doddaballapur on North-West, SH-85 towards Magadi on West, SH-87 towards Bannerghatta towards South and SH-104 towards Hennur. Key Plan of existing road network is given in Figure 1-1.

The existing road network within city includes core ring road of ~ 29 Km which covers Central Business Area of the city. The existing outer most road for the city is Outer Ring Road, 65 Km in length which was constructed by Bangalore Development Authority. Outer Ring Road has four lane configuration generally with service roads on both sides of main road for most of the length except ~ 10 Km. The right of way for ORR is 45m or less at some sections, which has been encroached by road side developments and hence, there is no scope for horizontal widening.

The existing outer most road for Bangalore City is 65 Km long Outer Ring Road. Outer Ring Road project was implemented with the intention of diverting long distance traffic, especially truck traffic away from the city roads. However, over a period of time, outer ring road has become a part of city road with development of residential and commercial establishments on both sides of the road. This has lead to increase in traffic along ORR. Based on the available statistics, the volume to capacity ratio at midblock section (away from junctions) is between 1.5 and 2 whereas the desirable ratio shall not more than 0.72 as per Indian Road Congress standard (IRC:106) for an urban road.

National Highway Authority of India (NHAI) has implemented elevated roads on Hosur Road (NH7) from Bommanahalli (close to Silk Board Junction on ORR) and Tumkur road (NH4)

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from Guraguntepalya junction on ORR and on Bellary road just after Hebbal junction upto Airport entry on NH-7. The elevated roads will increase the roadway capacity on existing road sections by taking away through traffic on elevated road and relieve traffic congestion beyond ORR. However, the traffic on elevated road should still pass through existing ORR and its interconnected road within the city limits which is already crowded. Hence, traffic dispersal at ORR and within the city roads are not eased.

Hence, it has become necessary to develop an alternative road facility away from ORR which will take away commercial and personalized vehicles entering city centre and at the same time relieve city roads of traffic congestion. Ideally, Bangalore city should have a circular ring road beyond existing ORR with connection to ORR and city through radial roads (primary and secondary roads). This will reduce traffic congestion on all radial roads, ORR and city roads.

Nandi Infrastructure Corridor Enterprises Limited (NICE) has implemented 45Km long 4 lane divided road between Hosur road (NH7) on south and Tumkur road (NH4) on west. This is a toll road for all traffic (passenger vehicles, commercial vehicles and T/w) using the stretch. At present commercial vehicles between Tumkur road and Hosur road which are not allowed on ORR are using the NICE road. The Right of Way for development of NICE road is 75m. Service roads are not provided on either side of main road.

The proposed PRR takes off on Tumkur road and terminates at Hosur road totaling 65 Kms. Bangalore city has radial road connected to ORR, it is necessary to develop an alternative concentric road around the city beyond ORR. Hence, it is advantageous to make use of existing access controlled NICE road and connected with proposed Peripheral Ring Road so that the final road network will be a “full circle” to Bangalore city.

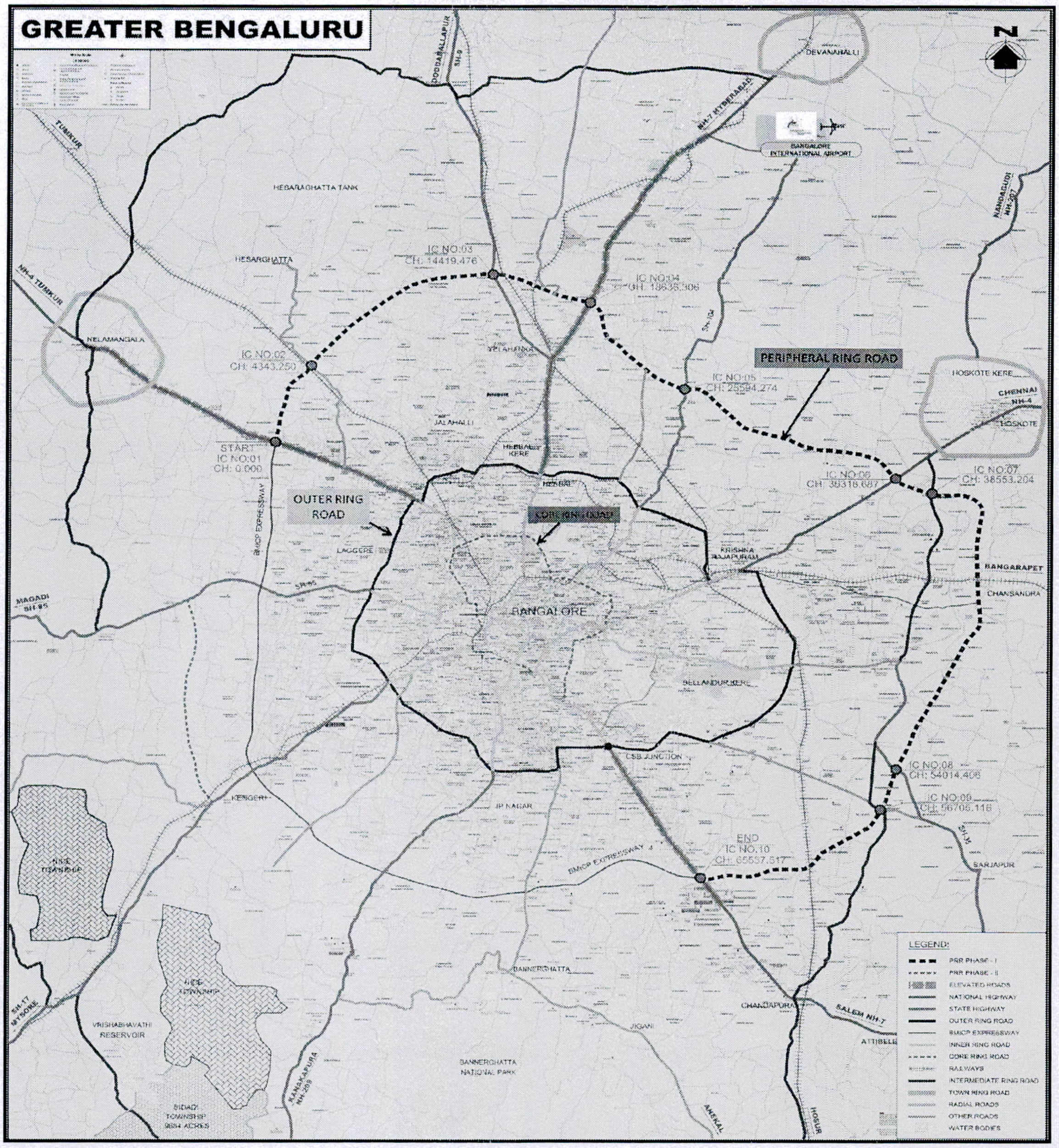
GREATER BENGALURU
N
DEVANAHALLI
BANGALORE INTERNATIONAL AIRPORT
NH-7 HYDERABAD
DODDABALLAPUR SH-9
TUMKUR
NANDAGUDI NH-207
HESARAGHATTA TANK
HESARGHATTA
NH-4 TUMKUR
NELAMANGALA
IC NO:03 CH: 14419.476
IC NO:04 CH: 18635.306
IC NO:02 CH: 4343.250
YELAHANKA
IC NO:05 CH: 25594.274
PERIPHERAL RING ROAD
HOSKOTE KERE
CHENNAI NH-4
HOSKOTE
START IC NO:01 CH: 0.000
JALAHALLI
HEBBAL KERE
HEBBAL
IC NO:06 CH: 39316.087
IC NO:07 CH: 38553.204
OUTER RING ROAD
CORE RING ROAD
BMICP EXPRESSWAY
LAGGERE
MAGADI SH-85
KRISHNA RAJAPURAM
BANGARAPET
CHANSANDRA
BANGALORE
BELLANDUR KERE
CSB JUNCTION
IC NO:08 CH: 54014.406
IC NO:09 CH: 56705.118
KENGERI
JP NAGAR
END IC NO:10 CH: 65537.517
BMICP EXPRESSWAY
SH-35
SARJAPUR
NICE TOWNSHIP
BANNERGHATTA
CHANDAPURA
SALEM NH-7
ATTIBELE
SH-17 MYSORE
VRISHABHAVATHI RESERVOIR
JIGANI
BANNERGHATTA NATIONAL PARK
KANAKAPURA NH-209
BIDADI TOWNSHIP 9684 ACRES
ANEKAL
HOSUR
LEGEND:
PRR PHASE - I
PRR PHASE - II
ELEVATED ROADS
NATIONAL HIGHWAY
STATE HIGHWAY
OUTER RING ROAD
BMICP EXPRESSWAY
INNER RING ROAD
CORE RING ROAD
RAILWAYS
INTERMEDIATE RING ROAD
TOWN RING ROAD
RADIAL ROADS
OTHER ROADS
WATER BODIES

Figure 1-1: Key Plan of Existing Major Road Networks

Bengaluru Development Authority (BDA) henceforth referred to as "Owner" is desirous in implementing 65km long Peripheral Ring Road between Tumkur Road and Hosur Road via Bellary Road and Old Madras Road. The proposed alignment of PRR will be located at a radial distance of 17 km - 25 km from city centre and acts as a bypass to the city for the long distance personalised vehicles (cars and cabs) and commercial vehicles (trucks and LCVs). The Key Plan of PRR alignment is given in Figure 1-2.

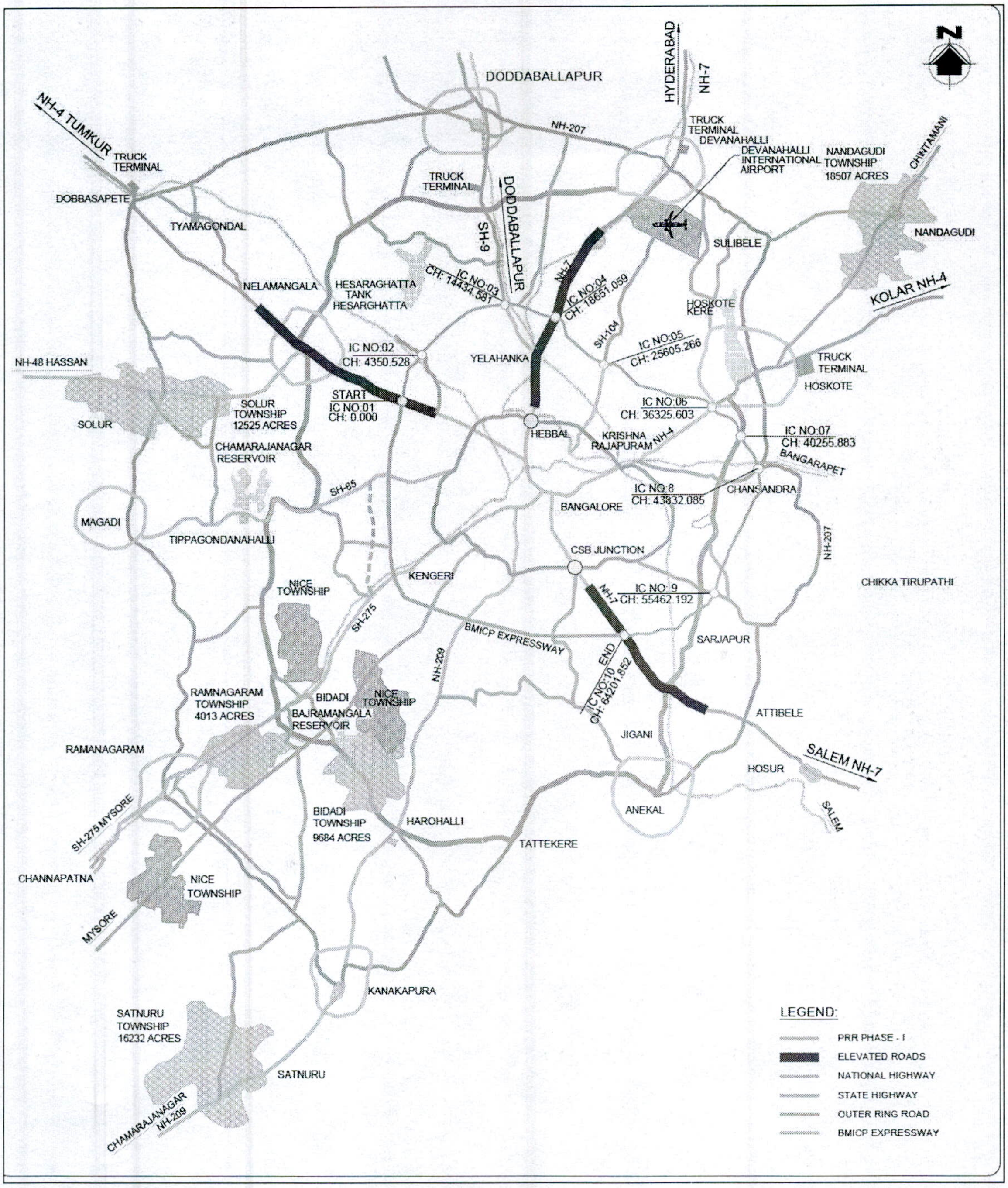
N
DODDABALLAPUR
HYDERABAD
NH-7
NH-4 TUMKUR
TRUCK TERMINAL
NH-207
TRUCK TERMINAL
DEVANAHALLI
DEVANAHALLI INTERNATIONAL AIRPORT
NANDAGUDI TOWNSHIP 18507 ACRES
CHINTAMANI
DOBBASAPETE
TRUCK TERMINAL
DODDABALLAPUR
SH-9
TYAMAGONDAL
SULIBELE
NANDAGUDI
NELAMANGALA
HESARAGHATTA TANK HESARGHATTA
IC NO:03 CH: 14434.581
NH-7
IC NO:04 CH: 18651.059
HOSKOTE KERE
KOLAR NH-4
SH-104
IC NO:02 CH: 4350.528
YELAHANKA
IC NO:05 CH: 25605.266
TRUCK TERMINAL
HOSKOTE
NH-48 HASSAN
START IC NO:01 CH: 0.000
SOLUR TOWNSHIP 12525 ACRES
SOLUR
IC NO:06 CH: 36325.603
HEBBAL
KRISHNA RAJAPURAM
NH-4
IC NO:07 CH: 40255.883
BANGARAPET
CHAMARAJANAGAR RESERVOIR
SH-65
IC NO:8 CH: 43832.085
CHANSANDRA
BANGALORE
MAGADI
TIPPAGONDANAHALLI
CSB JUNCTION
NH-207
NICE TOWNSHIP
KENGERI
IC NO: 9 CH: 55462.192
CHIKKA TIRUPATHI
SH-275
BMICP EXPRESSWAY
NH-7
SARJAPUR
NH-209
END IC NO:10 CH: 64201.852
RAMNAGARAM TOWNSHIP 4013 ACRES
BIDADI
NICE TOWNSHIP
BAJRAMANGALA RESERVOIR
ATTIBELE
JIGANI
RAMANAGARAM
SALEM NH-7
HOSUR
SH-275 MYSORE
BIDADI TOWNSHIP 9684 ACRES
HAROHALLI
ANEKAL
SALEM
TATTEKERE
CHANNAPATNA
NICE TOWNSHIP
MYSORE
KANAKAPURA
LEGEND:
PRR PHASE - I
ELEVATED ROADS
NATIONAL HIGHWAY
STATE HIGHWAY
OUTER RING ROAD
BMICP EXPRESSWAY
SATNURU TOWNSHIP 16232 ACRES
SATNURU
CHAMARAJANAGAR NH-209

Figure 1-2: Key Plan of PRR with existing Elevated Roads

1.3 Objectives

The proposed "Peripheral Ring Road" is 65 km long and connects 10 major Highways namely Tumkur Road(NH-4), Hesaraghatta Road(SH-39), Doddaballapura Road(SH-09), Bellary Road (NH-7), Hennur- Baglur Road (SH-104), OMR (NH-4), Whitefield road, Channasandra Main Road, Hoskote-Anekal Road(SH-35), Sarjapur Road and Hosur Road(NH-7). Overall, it intersects 4 National Highways and 6 state Highways. The proposed PRR length from start point on Tumkur road upto end point on Hosur road is 64.201 Km. Since, the alignment is getting integrated with NICE road on Tumkur road (~ 368m) and Hosur road (~ 546m), the total length of the project road is considered to be 65.115 Km.

The prime objectives of the proposed corridor are:

- To relieve congestion on the metropolitan area and the outer ring road.
- To provide linkage to the radial roads & Arterial roads.
- To connect the new urban nodes outside the city.
- To provide quick access to the international airport from strategic parts of the city

1.4 Revisions from earlier submissions

The consultant had submitted Draft DPR RN-05 Rev R(1) for the project in May 2013. The document was reviewed by Technical Team of JICA, BDA and DULT in addition to making project presentation to Technical Advisory Committee of BDA. Various aspects of the project discussed and conclusions drawn are summarized below:

- Revision in typical cross section to accommodate an exclusive 12m wide central median and paved shoulder of 1.5m with consequent changes in main road, service road and utility corridor.
- Minor revisions in traffic assignment based on joint review with JICA technical team
- Change of pavement type from flexible to rigid for main road.
- Revision in Bill of Quantities for change in project cross section
- Revision in Cost Estimate considering PWD SR 2013-14

Based on the revised inputs and details, the consultant had revised the DPR and submitted Final DPR as RN-05 Rev R(2) in August 2014.

The present submission of report incorporates the corrections carried out from RN-05 Rev R(3) document submitted in Aug 2014 to incorporate corrections in project cost estimate and traffic growth estimates.

Revision R(4) and R(5) of the document was carried out based on update for land acquisition costs provided by BDA.

GOK has asked BDA to take up the project. Hence, the earlier submitted Detailed Project Report has been modified taking into account the following:

- *Changes in project cross section elements, i.e, width of main road, service road, central median etc.,*
- *Change in pavement composition of main road from rigid pavement to flexible pavement.*
- *Fresh topography survey*
- *Geotechnical report / details at all interchange locations and railway crossing locations. .*
- *Updated Traffic survey and analysis*
- *Revised schedule of rates 2018-2019.*
- *Updated details / surveys for Environmental and Social Impact Assessment.*

This document is submitted to BDA as an advanced information.

-----XXXXX-----

SECTION – 2

TRAFFIC ANALYSIS AND FORECAST

2 TRAFFIC ANALYSIS AND FORECAST

2.1 Background

Bangalore Development Authority (BDA) proposes to develop Peripheral Ring Road (PRR) to Bangalore city between Tumkur road on West and Hosur road on South connecting National and State Highways. The main purposes of construction of PRR are:

- to provide alternate road facility for commercial vehicles and long distance passenger vehicles not having business in the city.
- to create new road network for the city thereby reducing traffic congestion on existing radial roads, their connectivity with existing outer ring road and outer ring road.

Traffic estimate forms an important input in planning, design and deciding the project structuring. Detailed information of traffic pattern and characteristics on existing facility is very important to assess traffic likely to use the new facility.

The consultant had carried out traffic surveys in 2007 at commencement of the project and had submitted reports. Since then, there have been many changes in project concept and project structuring. Further, the traffic scenario has considerably changed since 2007 with shift of airport from HAL to Devanahalli and development of layouts beyond ORR. Hence, it was found necessary to update the traffic statistics to the current year and the consultant had sought directions from Technical Advisory Committee (TAC) of BDA to suggest traffic projections to be adopted for the PRR project. On detailed deliberations, TAC suggested that fresh traffic surveys to be carried out at selected locations. Fresh traffic surveys were carried out in February / March 2012.

The revised traffic survey is carried out in January 2019 as per directions from BDA vide meeting at BDA on 01/12/2019 and at Vidhana Soudha on 06/12/2019. The details and type of traffic surveys was presented to Technical Advisory Committee and BDA and the same was approved on 16/01/2019. The revised traffic analysis is carried out and presented in this report.

2.2 Objectives

As per BDA's revised Terms of Reference for the project, the consultant is expected to determine likely divertible traffic on project road from existing major roads and generated traffic from development of layouts between ORR and PRR and beyond PRR. In general, the basic objectives of the traffic survey are:

- Carry out traffic midblock count at major roads where PRR intersects the alignment.

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- Carry out OD surveys for commercial and personalised vehicles.
- Carry out Number plate surveys at the same location of OD stations.
- Determination of Annual Daily Traffic, Seasonal Variation Factor, Peak hour traffic and Annual Average Daily Traffic.
- Estimation of traffic growth based on economic indicators
- Traffic assignment from Origin Destination surveys – mode wise.
- Analysis of OD surveys for commercial and personalised vehicles – desire line diagram, trip details, commodity details, trip purpose, etc.
- Estimation of tollable and non tollable traffic for each category of vehicles.
- Break up of single journey, return journey and monthly pass holders traffic for each category of vehicles.
- Computation of diverted traffic from existing road network.
- Computation of generated traffic based on available CDP considering development of PRR, satellite townships, development of area between ORR and PRR and beyond PRR.
- Preparation of detailed traffic analysis report covering existing traffic and likely traffic on PRR section wise.
- Traffic projections.

2.3 Project Sub-Sections

The project stretch totaling 65.115 Km crosses National Highways at 4 locations. BDA intends to take the project implementation in three sections simultaneously. The project is proposed to be taken up in three sections as given in Table 2-1.

Table 2-1: Project Sections

Stretch No	Starting	Ending	Length, Km
1	Km 0.000 (Tumkur road)	Km 18.367 (Bellary Road)	18.367
2	Km 18.367 (Bellary Road)	Km 36.323 (Old Madras Road)	17.956
3	Km 36.323 (Old Madras Road)	Km 65.115 (Hosur Road)	28.790

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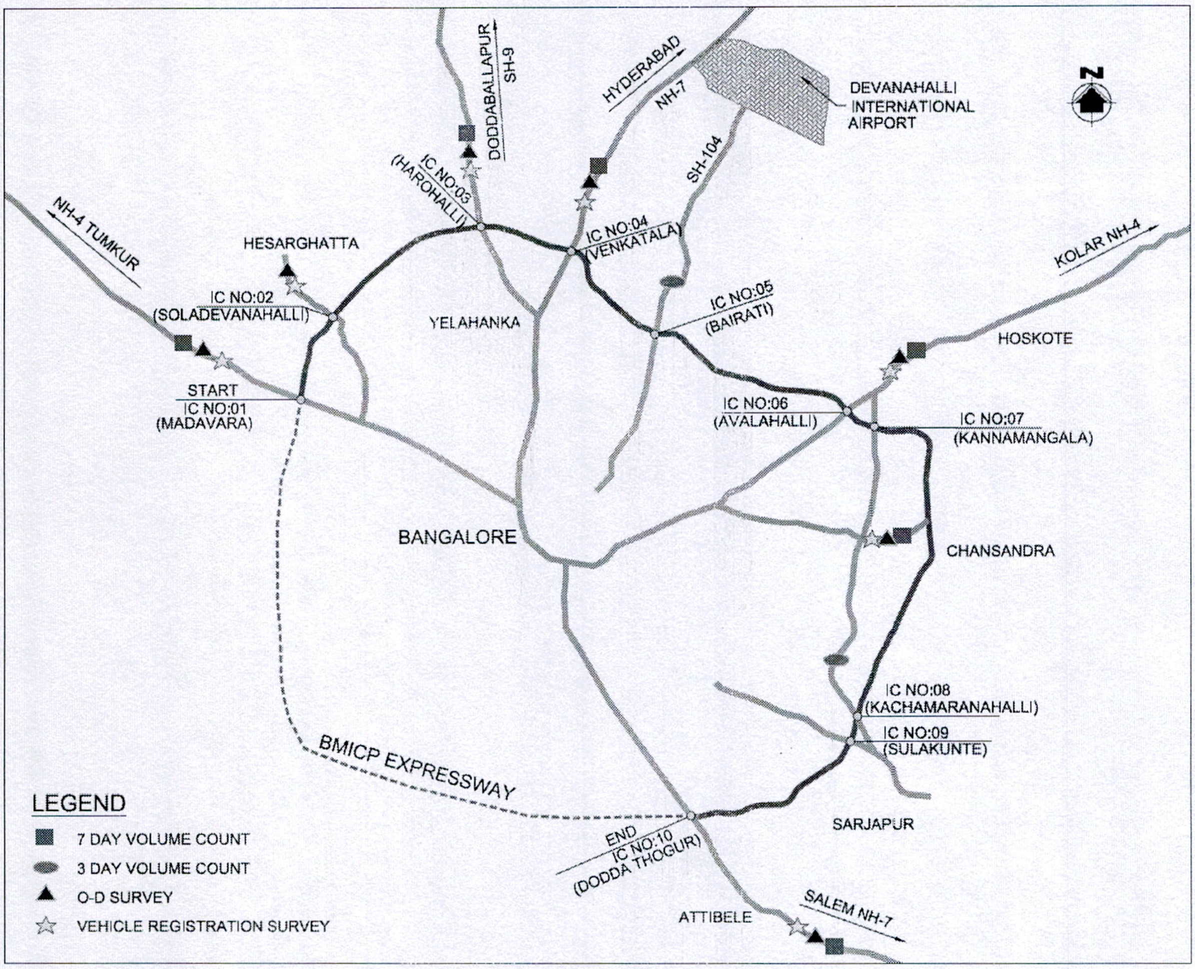
2.4 Traffic Surveys

The consultant has carried out various traffic surveys in consultation with client. Key Plan showing locations of various traffic surveys carried out earlier is given in Figure 2-1. Locations for traffic surveys carried out in Dec 2018 / Feb 2019 is given in Figure 2-2. Details of various field surveys with brief description of location are given in Table 2-2.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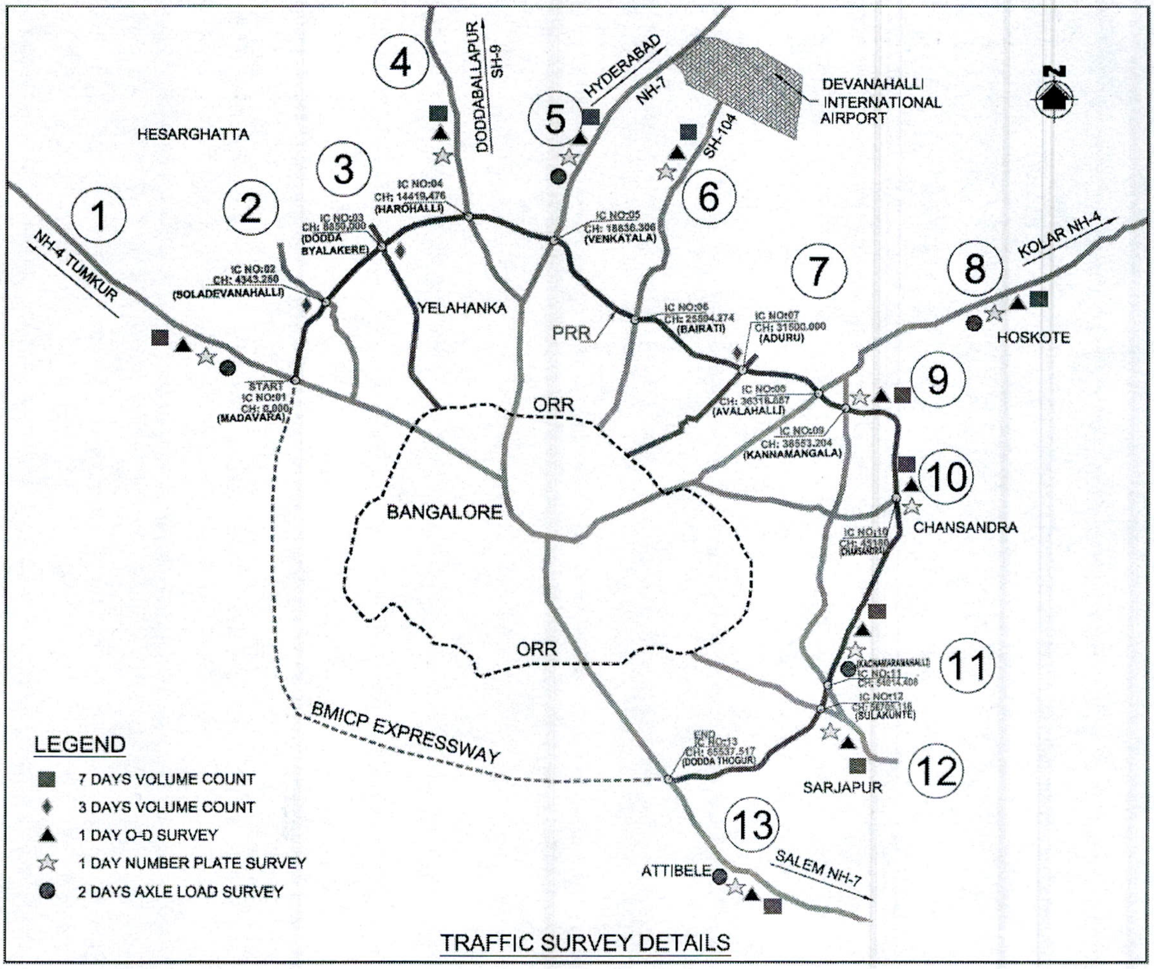
IC NO:04
(VENKATALA)
NH-4 TUMKUR
HESARGHATTA
IC NO:02
(SOLADEVANAHALLI)
YELAHANKA
IC NO:05
(BAIRATI)
KOLAR NH-4
HOSKOTE
START
IC NO:01
(MADAVARA)
IC NO:06
(AVALAHALLI)
IC NO:07
(KANNAMANGALA)
BANGALORE
CHANSANDRA
IC NO:08
(KACHAMARANAHALLI)
IC NO:09
(SULAKUNTE)
BMICP EXPRESSWAY
SARJAPUR
END
IC NO:10
(DODDA THOGUR)
ATTIBELE
SALEM NH-7
LEGEND
■ 7 DAY VOLUME COUNT
⬬ 3 DAY VOLUME COUNT
▲ O-D SURVEY
☆ VEHICLE REGISTRATION SURVEY

Figure 2-1: Key Plan showing Traffic Survey Locations (2012)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DODDABALLAPUR SH-9
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SH-104
DEVANAHALLI INTERNATIONAL AIRPORT
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NH-4 TUMKUR
KOLAR NH-4
HOSKOTE
YELAHANKA
PRR
ORR
BANGALORE
CHANSANDRA
BMICP EXPRESSWAY
SARJAPUR
ATTIBELE
SALEM NH-7
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START IC NO:01 CH: 0.000 (MADAVARA)
IC NO:02 CH: 4343.250 (SOLADEVANAHALLI)
IC NO:03 CH: 8850.000 (DODDA BYALAKERE)
IC NO:04 CH: 14419.476 (HAROHALLI)
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IC NO:07 CH: 31500.000 (ADURU)
IC NO:08 CH: 36318.087 (AVALAHALLI)
IC NO:09 CH: 38553.204 (KANNAMANGALA)
IC NO:10 CH: 45180 (CHUSANDRA)
(KACHAMARANAHALLI) IC NO:11 CH: 54814.408
IC NO:12 CH: 58785.118 (SULAKUNTE)
END IC NO:13 CH: 65537.517 (DODDA THOGUR)
LEGEND
■ 7 DAYS VOLUME COUNT
♦ 3 DAYS VOLUME COUNT
▲ 1 DAY O-D SURVEY
☆ 1 DAY NUMBER PLATE SURVEY
● 2 DAYS AXLE LOAD SURVEY
TRAFFIC SURVEY DETAILS

Figure 2-2: Key Plan showing Traffic Survey Locations (2018/2019)

Table 2-2: Traffic Survey Locations (2018/2019)

Sl No	Location	Midblock Count	OD Survey	Number Plate Survey	Axle Load Survey
1	Tumkur road (near Nelamangala Toll Plaza)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	1 day, 24 hours
2	Hessaraghatta Road	3 day continuous	-	-	-
3	IIHR Road	3 day continuous	-	-	-
4	Doddaballapur Road	7 days count continuous	1 day, 24 hours	1 day, 24 hours	1 day, 24 hours
5	Bellary Road (near Trumpet interchange)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	1 day, 24 hours
6	Hennur road (near Kannur)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	-
7	Adur Cross	3 day continuous	-	-	-
8	Old Madras Road (Hosakote, near Toll Plaza)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	1 day, 24 hours
9	Whitefield (near Kannamangala)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	-
10	Channasandra	7 days count continuous	1 day, 24 hours	1 day, 24 hours	-
11	Sarjapura Road (near Dommasandra)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	-
12	Anekal Road (near Marasur Gate)	7 days count continuous	1 day, 24 hours	1 day, 24 hours	-
13	Hosur Road	7 days count continuous	1 day, 24 hours	1 day, 24 hours	1 day, 24 hours

2.4.1 Traffic Analysis - General

The traffic surveys (as per latest proposal) is completed and analysis carried out. These are presented in following sections.

2.4.2 Classified Traffic Volume Count Survey (TVC)

Classified traffic volume counts were taken at locations and for the time period mentioned in Table 2-2. The surveys were conducted between 15-12-2018 and 14-01-2019. The survey was carried out by ATCC. For effective vehicle counts, vehicle classification used in the study were grouped under motorised and non motorised categories. The vehicles passing through the survey stations were enumerated in each direction separately in accordance with the vehicle classification system given in IRC as minimum.

2.4.3 Origin Destination Survey (OD)

Origin and Destination survey was organised for both passenger and freight carriers over a period of 24 hours on a normal working day for the above mentioned locations nearby. Survey was conducted between 28-12-2018 and 18-01-2019. Roadside interview (RSI) method is adopted with random sampling basis obtaining a minimum desired sample size. The objective of the Origin-Destination (O-D) survey is to gather information regarding travel characteristics of different users on the project road. Results of the O-D surveys are used to describe the user characteristics, both for passengers and goods vehicles.

2.4.4 Vehicle Registration Survey (VR)

The number of commercial vehicles with its registration number with / without National Permits and passenger vehicles with registration number will be noted down at the survey location for a period of 24 hours. The data will be used in estimation of commercial vehicles with NP and Passenger vehicles within the city limits based on the registration. These data can be used in estimation of toll revenue based on the policy decision by BDA.

2.4.5 Speed and Delay Survey

Speed and delay survey was carried out by the consultant by moving car method at various sections of existing ORR and radial road networks, where commercial and passenger traffic ply. Summary of journey speed at various sections are given in Table 2-3.

Table 2-3: Speed Profile at various sections

From	To	Route	Journey Speed, Kmph
Mekhri Circle	Trumpet Interchange	Via Hebbal flyover	42.16
Tumkur road (via Gorguntepalya)	Hebbal	Outer Ring Road	18.89
Whitefield	Hebbal	Outer Ring Road	16.71
Electronic City	Hebbal	NICE road	47.92
Electronic City	Hebbal	Central Silk Board, Mekhri circle	16.58
Electronic City	Hebbal	Central Silk Board, KR Puram	15.56

2.5 PCU Factors adopted

The consultant has carried out various analysis from the data collected during field surveys, which are given in this section. Traffic counts of each vehicle type are converted into equivalent Passenger Car Unit using factors given in IRC:106-1990. PCU factors used in the analysis are given in Table 2-4.

Table 2-4: PCU Factors considered

Vehicle Type	PCU Factors for composition of vehicles	
	5%	10% or more
Two Wheeler	0.5	0.75
Auto (passenger)	1.2	2.0
Auto (Goods)	1.2	2.0
Car / Jeep / Van	1.0	1.0
Mini bus	1.4	2.0
Standard Bus	2.2	3.7
LCV (4 wheeler)	2.2	3.7
LCV (6 wheeler)	2.2	3.7
2 Axle truck	2.2	3.7
3 Axle truck	2.2	3.7
MAV (4 to 6 axle)	2.2	3.7

Vehicle Type	**PCU Factors for composition of vehicles**	
	5%	**10% or more**
OSV (> 6 axle)	2.2	3.7
Others (HCM / EME)	2.2	3.7
Agricultural tractor	4.0	5.0
Agricultural tractor trailer	4.0	5.0
Cycle	0.4	0.5
Animal drawn vehicles	1.5	2.0

2.6 Analysis of Traffic Volume Count Survey

Traffic volume count surveys carried out and compiled and analysis is carried out to derive the following information:

- Average Daily Traffic (ADT) for fast and slow moving vehicles
- Average Daily variation
- Traffic Composition
- Annual Average Daily Traffic after applying seasonal correction factor

2.6.1 Average Daily Traffic (ADT)

Traffic volume count carried out at selected locations was averaged to determine the Average Daily Traffic (ADT). ADT is classified under tollable and non tollable vehicles and abstract is given in Table 2-5.

Table 2-5: Average Daily Traffic at Various Locations

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
Car / Jeep (white board)	15870	1711	903	5822	33584	2220	2812	11092	7609	1672	4200	9473	2690
Car / Jeep (yellow board)	27272	2017	1444	5083	50839	3796	1580	12779	9010	2521	7604	16717	3298
LCV / Tempo Traveller	5499	1206	449	1986	3416	1189	1213	5265	2298	1446	1532	4061	976
LCV - Goods	3718	125	25	484	570	232	112	1221	101	288	152	397	12
Mini Buses	544	21	7	240	613	20	1	146	60	78	24	599	25
Buses	4872	667	162	1294	2731	542	165	3866	845	583	1077	3547	730
2 Axle Trucks	3278	415	120	587	1944	505	377	3567	1197	683	699	6611	464
3 Axle Trucks	2696	191	37	360	1497	368	194	1702	683	780	1006	4983	228
4 to 6 Axle Trucks	5216	30	5	358	1170	43	42	1103	376	236	275	4049	72

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
7 or more Axle Trucks	2	0	0	0	9	1	0	1	0	0	1	7	0
HCE / EME	2	0	0	0	9	1	0	1	0	0	1	7	0
Total Tollable Vehicles, No	68967	6383	3152	16214	96373	8916	6496	40742	22179	8287	16570	50444	8495
Total Tollable Vehicles, PCU	92148	8487	3733	20417	107034	11243	7960	55682	26884	11750	20923	75503	10693
T/w	27379	10365	7903	18397	22843	8687	7624	33232	12640	12065	17538	29762	14456
Auto	2014	693	259	909	562	721	734	2635	778	470	588	263	513
Exempted Vehicles	81	4	2	28	64	6	2	40	14	6	7	14	12
Tractor	9	1	3	11	17	12	2	18	5	13	5	4	13
Tractor Trailer	19	23	3	84	41	201	15	113	57	65	49	19	84
Cycles	12	91	58	66	83	32	17	93	149	119	43	57	17

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
Animal Drawn	9	7	0	14	21	12	2	15	24	13	6	11	7
Total Non Tollable Vehicles, No	29523	11184	8228	19509	23631	9671	8396	36146	13667	12751	18236	30130	15102
Total Non Tollable Vehicles, PCU	23198	8757	6288	15362	18197	8277	6680	28732	10787	10005	14113	22791	11882
Total, No	98490	17567	11380	35723	120004	18587	14892	76888	35846	21038	34806	80574	23597
Total, PCU	115346	17244	10021	35779	125231	19520	14640	84414	37671	21755	35036	98294	22575

2.6.2 Seasonal Variation Factor

Traffic Survey for the project road was carried out between Dec 2018 and Feb 2019. There would be variation in traffic amongst various months of a year. Normally the seasonal variation factors will be arrived based on the past traffic survey at the locations over the year in each month, if details are available. In absence of the month-wise traffic data of past years, seasonal variation factors will be estimated based on the sale of Petrol and Diesel in the study area or sale of fuel at the fuel stations located on the study corridor. For the project, sale of fuel was collected for each month at three different locations covering the project road. Seasonal variation factor for the month when survey was carried out is established as the factor between the sales of petrol / high speed diesel of the month to the average for the year. Summary of seasonal factors for three locations are given in Table 2-6.

Table 2-6: Seasonal Variation Factors Adopted

Month	Petrol Sales	Diesel Sales
January	1.09	1.15
February	1.12	1.18
March	1.01	1.04
April	1.06	1.08
May	0.99	1.06
June	1.03	1.09
July	0.94	0.94
August	0.92	0.87
September	0.87	0.87
October	0.9	0.87
November	1.13	0.96
December	**1.03**	**1.01**

2.6.3 Annual Average Daily Traffic (AADT)

Annual Average Daily Factor is calculated by multiplying seasonal variation factor with Annual daily Traffic. Seasonal variation factors for petrol is used to compute AADT for passenger cars, T/w, Auto and SCF for diesel is used to compute AADT for commercial vehicles and buses. Summary of AADT is given in Table 2-7.

Table 2-7: Annual Average Daily Traffic at various count locations

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
Car / Jeep (white board)	16347	1763	930	5996	39048	2287	2896	11425	7837	1722	4326	9757	2771
Car / Jeep (yellow board)	27545	2037	1458	5134	58324	3834	1596	12907	9100	2546	7680	16885	3331
LCV / Tempo Traveller	4880	963	397	1728	3774	767	1161	4693	2055	1247	1418	3700	899
LCV - Goods	4430	381	82	767	1561	668	177	1858	368	504	284	803	99
Mini Buses	549	21	7	242	726	20	1	147	61	79	24	605	25
Buses	4921	674	164	1308	3660	547	167	3905	854	589	1087	3582	737
2 Axle Trucks	3311	419	121	593	2679	510	381	3603	1209	690	706	6677	469
3 Axle Trucks	2723	193	37	364	2108	372	196	1719	690	788	1016	5033	230
4 to 6 Axle Trucks	5268	30	5	362	1622	43	42	1114	380	238	278	4089	73

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
7 or more Axle Trucks	2	0	0	0	14	1	0	1	0	0	1	7	0
HCE / EME	2	0	0	0	14	1	0	1	0	0	1	7	0
Total Tollable Vehicles, No	69976	6481	3201	16494	98008	9049	6617	41372	22554	8403	16820	51138	8634
Total Tollable Vehicles, PCU	93390	8606	3788	20741	108775	11399	8096	56462	27307	11901	21216	76447	10854
T/w	28200	10676	8140	18949	30884	8948	7853	34229	13019	12427	18064	30655	14890
Auto	2074	714	267	936	831	743	756	2714	801	484	606	271	528
Exempted Vehicles	81	4	2	28	68	6	2	40	14	6	7	14	12
Tractor	9	1	3	11	20	12	2	18	5	13	5	4	13
Tractor	19	23	3	85	62	203	15	114	58	66	49	19	85

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Location	Tumkur Road	Hessaraghatta Road	IIHR	Doddaballapura Road	Airport (Bellary) Road	Hennur Road	Addur Cross	Old Madras Road	Whtefield Road	Channasandra Road	Sarjapura Road	Hosur Road	Anekal Road
Trailer													
Cycles	12	91	58	66	109	32	17	93	149	119	43	57	17
Animal Drawn	9	7	0	14	26	12	2	15	24	13	6	11	7
Total Non Tollable Vehicles, No	30404	11516	8473	20089	24334	9956	8647	37223	14070	13128	18780	31031	15552
Total Non Tollable Vehicles, PCU	23886	9015	6475	15812	18732	8507	6879	29578	11103	10297	14529	23470	12230
Total, No	100380	17997	11674	36583	122342	19005	15264	78595	36624	21531	35600	82169	24186
Total, PCU	117276	17621	10263	36553	127507	19906	14975	86040	38410	22198	35745	99917	23084

Summary of ADT and AADT are given in Table 2-8 for ready reference.

Table 2-8: Comparison of ADT and AADT

Location	ADT		AADT	
	Nos	PCUs	Nos	PCUs
Tumkur Road	98490	115346	100380	117276
Hessaraghatta Road	17567	17244	17997	17621
IIHR Road	11380	10021	11674	10263
Dodaballapur Road	35723	35779	36583	36553
Bellary Road	120004	125231	122342	127507
Hennur Road	18587	19520	19005	19906
Addur Cross	14892	14640	15264	14975
Old Madras Road	76888	84414	78595	86040
Whitefield Road	35846	37671	36624	38410
Channasandra Road	21038	21755	21531	22198
Hoskote Sarjapur Road	34806	35036	35600	35745
Hosur Road	80574	98294	82169	99917
Anekal Road	23597	22575	24186	23084

2.6.4 Hourly Variation of traffic

Hourly variation in traffic at all traffic count stations reveal that the peak duration in traffic is in the evening between 1600 hours to 1900 hours. Generally, traffic at late evening and early morning is lean. Graphical representation of hourly variation in traffic is given in Figure 2-3.

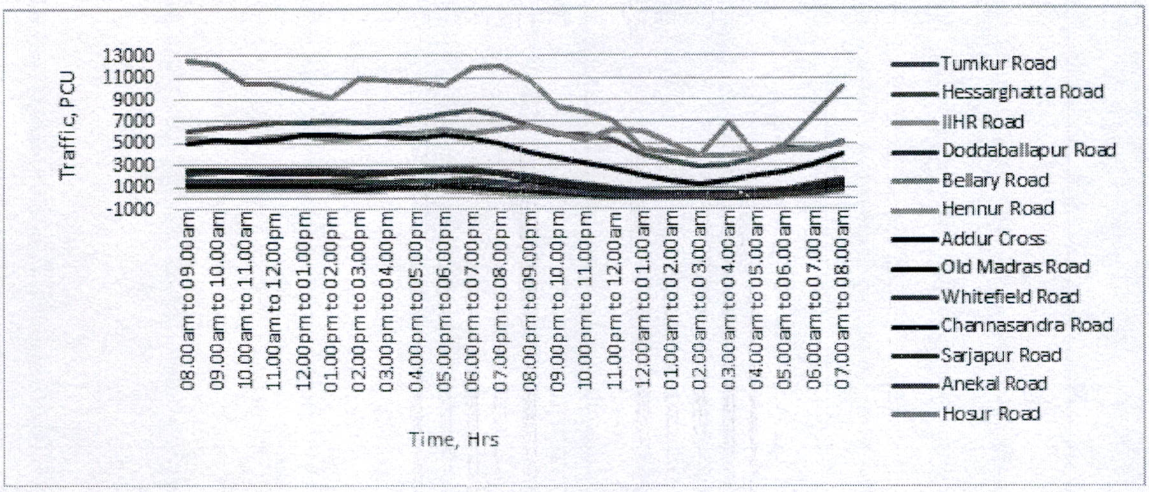

Figure 2-3: Hourly Variation in Traffic at various locations

Variation in traffic between various days of the week is presented in Figure 2-4. There is not much variation between various days of the week.

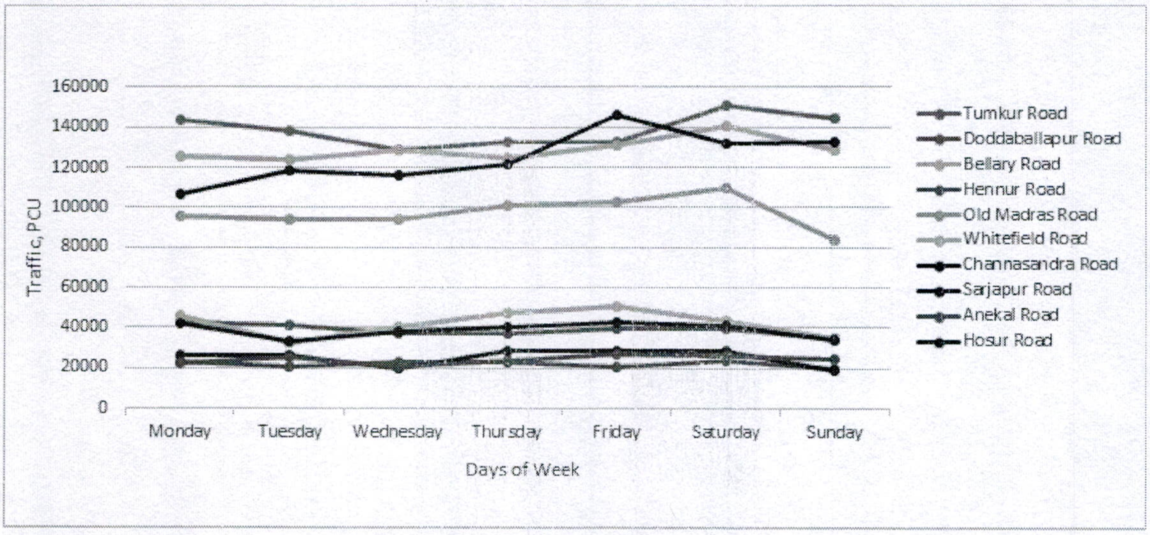

Figure 2-4: Daily Variation in Traffic at all count locations

2.6.5 Traffic Composition

Traffic composition at all traffic count locations are computed from the traffic count and is presented in Table 2-9. Pictorial representation of traffic composition at three homogenous section is given from Figure 2-5 to Figure 2-7.

Following can be inferred:

- Proportion of tollable vehicles various between 64% and 80% at all NHs.

- Passenger car proportion is between 21% and 74% at all locations with 72% at Bellary road.
- Truck proportion on NHs varies between 12% and 21%.

Table 2-9: Traffic Composition at Count Locations

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Car / Jeep (white board)	16.1%	9.7%	7.9%	16.3%	28.0%	11.9%	18.9%	14.4%	21.2%	7.9%	12.1%	11.8%	11.4%
Car / Jeep (yellow board)	27.7%	11.5%	12.7%	14.2%	42.4%	20.4%	10.6%	16.6%	25.1%	12.0%	21.8%	20.7%	14.0%
LCV / Tempo Traveller	5.6%	6.9%	3.9%	5.6%	2.8%	6.4%	8.1%	6.8%	6.4%	6.9%	4.4%	5.0%	4.1%
LCV - Goods	3.8%	0.7%	0.2%	1.4%	0.5%	1.2%	0.8%	1.6%	0.3%	1.4%	0.4%	0.5%	0.1%
Mini Buses	0.6%	0.1%	0.1%	0.7%	0.5%	0.1%	0.0%	0.2%	0.2%	0.4%	0.1%	0.7%	0.1%
Buses	4.9%	3.8%	1.4%	3.6%	2.3%	2.9%	1.1%	5.0%	2.4%	2.8%	3.1%	4.4%	3.1%
2 Axle Trucks	3.3%	2.4%	1.1%	1.6%	1.6%	2.7%	2.5%	4.6%	3.3%	3.2%	2.0%	8.2%	2.0%
3 Axle Trucks	2.7%	1.1%	0.3%	1.0%	1.2%	2.0%	1.3%	2.2%	1.9%	3.7%	2.9%	6.2%	1.0%
4 to 6 Axle Trucks	5.3%	0.2%	0.0%	1.0%	1.0%	0.2%	0.3%	1.4%	1.0%	1.1%	0.8%	5.0%	0.3%
7 or more Axle Trucks	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HCE / EME	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
T/w	27.8%	59.0%	69.4%	51.5%	19.0%	46.7%	51.2%	43.2%	35.3%	57.3%	50.4%	36.9%	61.3%

Vehicle Category	VC-1	VC-2	VC-3	VC-4	VC-5	VC-6	VC-7	VC-8	VC-9	VC-10	VC-11	VC-12	VC-13
Auto	2.0%	3.9%	2.3%	2.5%	0.5%	3.9%	4.9%	3.4%	2.2%	2.2%	1.7%	0.3%	2.2%
Exempted Vehicles	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%
Tractor	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%
Tractor Trailer	0.0%	0.1%	0.0%	0.2%	0.0%	1.1%	0.1%	0.1%	0.2%	0.3%	0.1%	0.0%	0.4%
Cycles	0.0%	0.5%	0.5%	0.2%	0.1%	0.2%	0.1%	0.1%	0.4%	0.6%	0.1%	0.1%	0.1%
Animal Drawn	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

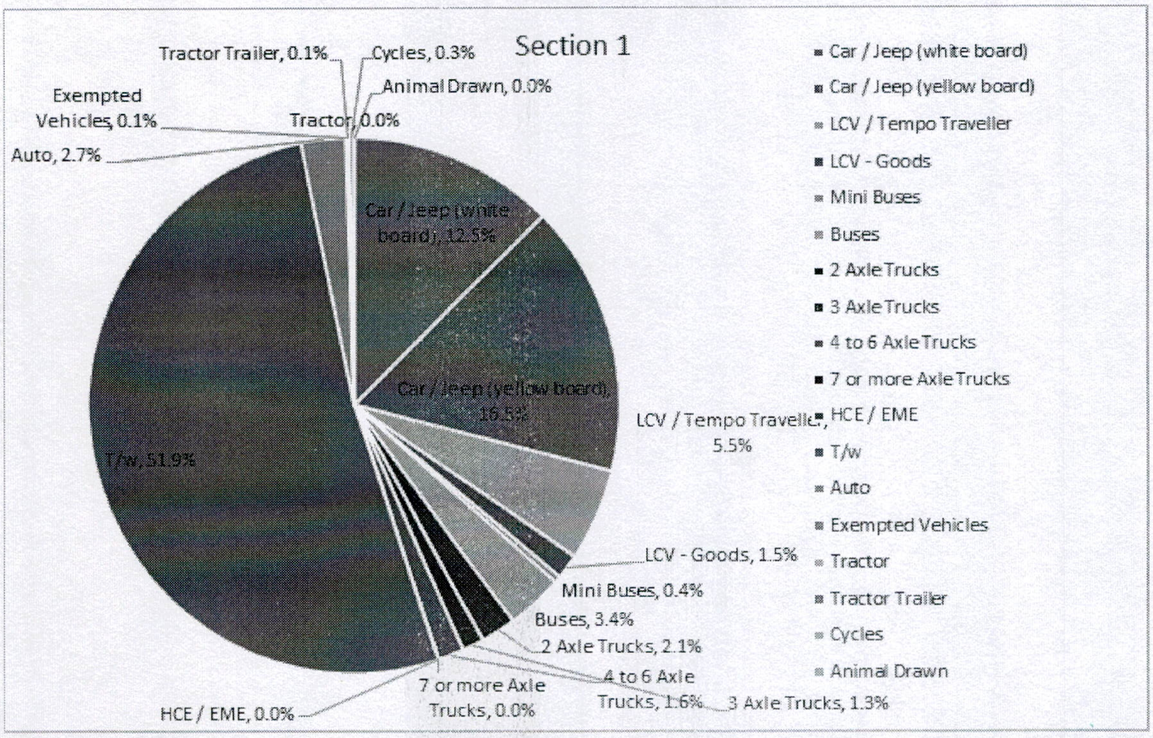

Figure 2-5: Traffic Composition, Section-1

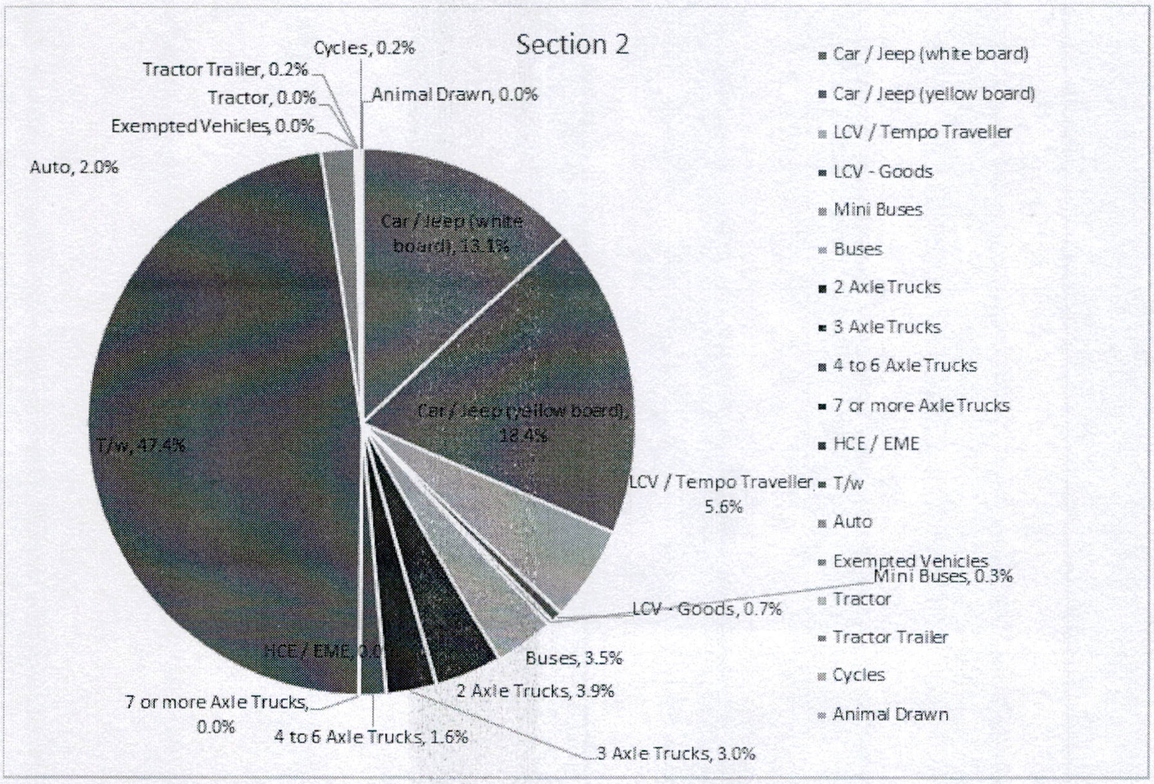

Figure 2-6: Traffic Composition, Section-2

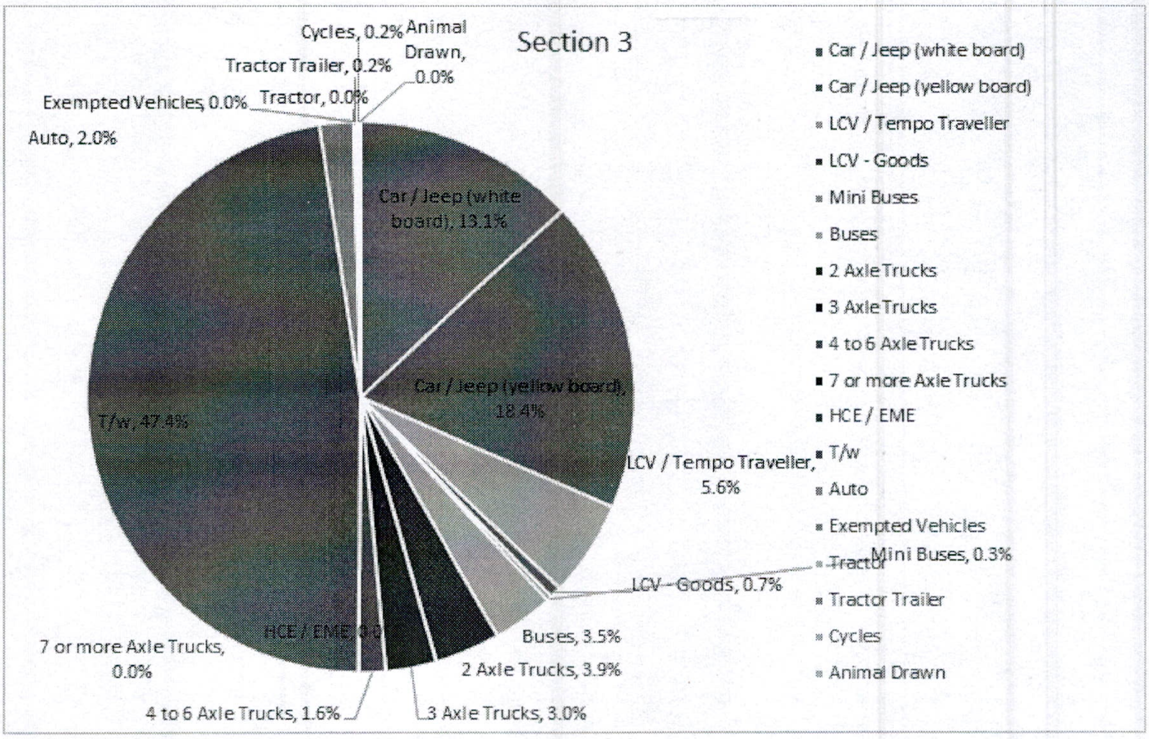

Figure 2-7: Traffic Composition, Section-3

2.7 Origin Destination Studies

2.7.1 General

Origin and Destination survey was organised for both passenger and freight carriers over a period of 24 hours on a normal working day at locations given in Table 2-9. Roadside interview (RSI) method was adopted to capture required information from the vehicle users. The objective of the Origin-Destination (O-D) survey is to gather information regarding travel characteristics of different users on the project road. Results of the O-D surveys are used to describe the user characteristics, both for passengers and goods vehicles which will help in assessing the traffic on the proposed PRR based on the Origin and Destination information gathered during the survey.

2.7.2 Zoning System

For the purpose of the study, in order to estimate the travel pattern, totally 49 zones have been considered. The pre-defined zone indicates the inter-zonal and intra-zonal traffic movement which facilitates in assessing the through traffic on the project road. The zoning system is presented in Table 2-10 and Figure 2-8.

Table 2-10: List of OD Zones Considered

Zone No.	Details of Zones
1	North India (Including J & K, Punjab, Himachal Pradesh, Haryana, Delhi, Rajasthan, Uttaranchal, Uttarpradesh, Jharkhand, Bihar)
2	North Eastern India (Including West Bengal, Chattisgarh, Orissa, North Eastern States)
3	Gujarat, Maharashtra, Goa
4	Uttara Kannada, Belgaum, Dharwad, Hubli, Haveri
5	Bijapur, Gulbarga, Bidar
6	Raichur, Bellary, Koppal
7	Davangere, Sira, Hiriyuru, Chitradurga
8	Mangalore, Udapi, Chikkamagalur, Shimoga
9	Hassan, Chennarayapatna, Kunigal
10	Tumkur City and Sorrounding area, Gubbi, Turuvekere, Tiptur, Chikkanayakanahalli, Koratagere, Madhugiri, Pavagada
11	Dabbaspete, Sompura (Dabbaspete) Industrial Area, Hirehalli Industrial Area
12	T.Begur Industrial Area, Thayamagondlu Industrial Area (between Nelamangala and Dabbaspete)
13	Nelamangala and surrounding areas towards Bangalore
14	Doddaballapur, Hindupura, Gouribidanur
15	Yeshwanthpur, Subedarpalya, (Ashoknagar), Aswathnarayanapura, Gokul Extension, Lottegollahalli, Mattikere, Indian Institute of Science, Medarlinganahalli, Dyavasandra, Divanarapalya, Kempegowda Tower, Rajamahalvilas extension, Sadashivanagar extension, Geddalahalli, Nagashettihalli, Purnapura
16	Yelahanka, Rajanakunte
17	Devanahalli, Srinivasapura, Chintamani, Siddlagatta, Chikkaballapura, Bagepalli
18	Bangalore International Airport

Zone No.	Details of Zones
19	Banasavadi RS, Ramaswamipalya, Kammanahalli, Saitpalya, Kariyannapalya, Venkateshpura, Ashokanagara, East RS, Kadrampalya, Cox Town, Cooke Town, Munireddipalya, Sagayapuram, Periyarnagar, Ambedkarnagar, Ramnatanagara, Mattadahalli, Cholanayakanahalli, Ramnatanagara, Dinnuru, Sultanpalya, Govindapura, Annaiyappa Block, Shampura, Lingarajapuram, Kaval Byrasandra, Kadugondanahalli, Kacharakanahalli, Hebbal, Devarajivanahalli, Chikka Banasvadi, Krishnaiyanpalya, Krishnamurthynagara, Baiyyappanahalli.
20	Austin Town, Nilasandra, Sonenhalli, Domlur, Dukanahalli, Appareddipalya, Indiranagar, Amblipura, Vanganahalli, Bellandur, Devarabisanahalli, Panathur, Kariyammana Agrahara, Dinnepalya, Kadbisanhalli, Kempapura, Yamalur, Marathalli, Mahadevapura, Narayanapura, Doddanekkundi, Kaggadasapura, Malleshappanapalya, Bairasandra, Garkamantapalya, Nagavara, Annasandrapalya, Vibhutipura, Belur, Jakasandra, Kattalpalya, Mistripalya, Agara, Venkatapura, Challaghatta, Kodihalli, Murugesapalya, Konenagrahara, Belur Nagasandra, Vimananagara, Ugrampalya, Tippasandra, Suddaguntepalya, Jogupalya, Koramangala, Koramangala Extension, Channappanahalli, Yellukunte
21	Hyderabad, Vijayawada, Rest of Andhra Pradesh
22	Hosakote, Kolar, Malur, Bangarpete, Mulbagal, Narasapura, Vamagallu
23	Chanasandra, Konenaagraharam, Domasandra, Dobanahalli, Virenahalli, Virgonagar, Chinnagenahalli, Avalhalli, Kadgodi Colony, Whitefield RS, Belattur, Chikkabanhalli, Kodi, Tigalarpalya, Pattandur Agrahara, Sonenhalli, Sadaramangala, Singayyanapalya, Gosala, Garudacharpalya, Kotteppa Gudisalu, Krishnarajapuram RS, Immadihalli, Nagondanhalli, Hale Devasandra, Hosa Devasandra, Hosa Basavanapura, Hale Basavanapura, Shigehalli, Kodagihalli, Whitefield, Kundalhalli, Nallurhalli, Hudi, Kadgodi, Hagadur
24	Tirupathi, Chandragiri, Renigunta, Erpedu, Srikalahasti
25	Jangamakote, H Cross, Malamachanahalli and Shidlagatta
26	Malur, Narasapura,Vamagallu
27	KGF, Robertsonpet, BEML nagar, Kuppam
28	Sarjapura
29	Gunjur, Dommasandra
30	Varthur, Whitefield, Kadagodi
31	Attibele

Zone No.	Details of Zones
32	Anekal, Bannerghatta
33	Electronics City
34	Chandapura, Bommasandra Industrial Area
35	High Court, City RS, Guttahalli, (Rajamahal), Kumara Park, Seshadripuram, Gandhinagar, Akkipete, Balepete, Chikpete, Cubbonpete, Shantinagar, Ashoknagar, Richmond Town, Tasker Town, Shivajinagar, Russel Market, Pottery Town, Fraser Town, Benson Town, Jayamahal, Williams Town, Murphy Town, Ulsoor, Gautampuram, Ramachandrapur, Dayanandanagar, Raj Bhavan, Chinnappa Garden, Mudaliar Garden, Muddamma Garden, Annaiyappa Block
36	Basavanagudi, Sudhamanagar, Langford Town, Gautampuram, Nainappasettipalya, Tata Silk Farm, Bairasandra Extension, Jayanagar, Tilaknagar, Adugodi, Lakasandra, Sadduguntapalya, Chikka Adugodi, Gurappanapalya, Chikka Madivala, Marenahalli, Rupena Agrahara, Madivala, Sarakki , J P Nagar
37	Guddadahalli, Karithimmanahalli, Devati Ramanahalli, Gandhi Bazar, Hanumanthanagar, Dasarahalli, Narasimharaja Colony, Visvesvarapuram, Gavipuram, Padarayanapura, Binnypete, City Market, Hosa Tharugupete, Chamarajpet, Kalasipalya, Rayapuram, Alvadipalya, Byatrayanapura, Tyagarajanagar, Yediyur, Avalhalli, Hokerehalli, Pantarapalya, Banashankari, Kadarenahalli, Kathreguppe, Ittamadu
38	Bangalore University Campus, Kurubahalli, Mallesvaram, Hanumantanagar, Sajjepalya, Katigepalya, Beggar Colony, Kamakshipalya, Papareddipalya, Malegalu, Thimmanahalli, Mudalapalya, Attikuppe, Malathalli, Laripalya, Cholurpalya, Rajajinagar, Prakashnagar, Srirampuram, Agrahara Dasarahalli, Bhashyamnagar, Hanumantapura, Lakshminarayanapuram, Ketmaranahalli, Vayyalikaval, Nagapura, Mahalakshmipura, Rajajinagar, Industrial Sub Urb, Yesvantpur, Industrial Sub Urb, Gayatrinagar, Goraguntepalya, Goraguntepalya, Subramanyanagar, Saneguruvanahalli, Nagarbhavi, Sivanahalli, Muddaiyanpalya, Nayandahalli
39	Ramanagara, Mandya
40	Mysore, Malavalli, Kanakapura
41	Hosur, Krishnagiri,
42	Salem, Dhrmapuri, Erode, Coimbatore
43	Madurai, Namakkal, Trichy, Karur, Tirunelveli, Kanyakumari Districts
44	Chennai, Kanchipuram, Arkkonam, Tiruvallur District

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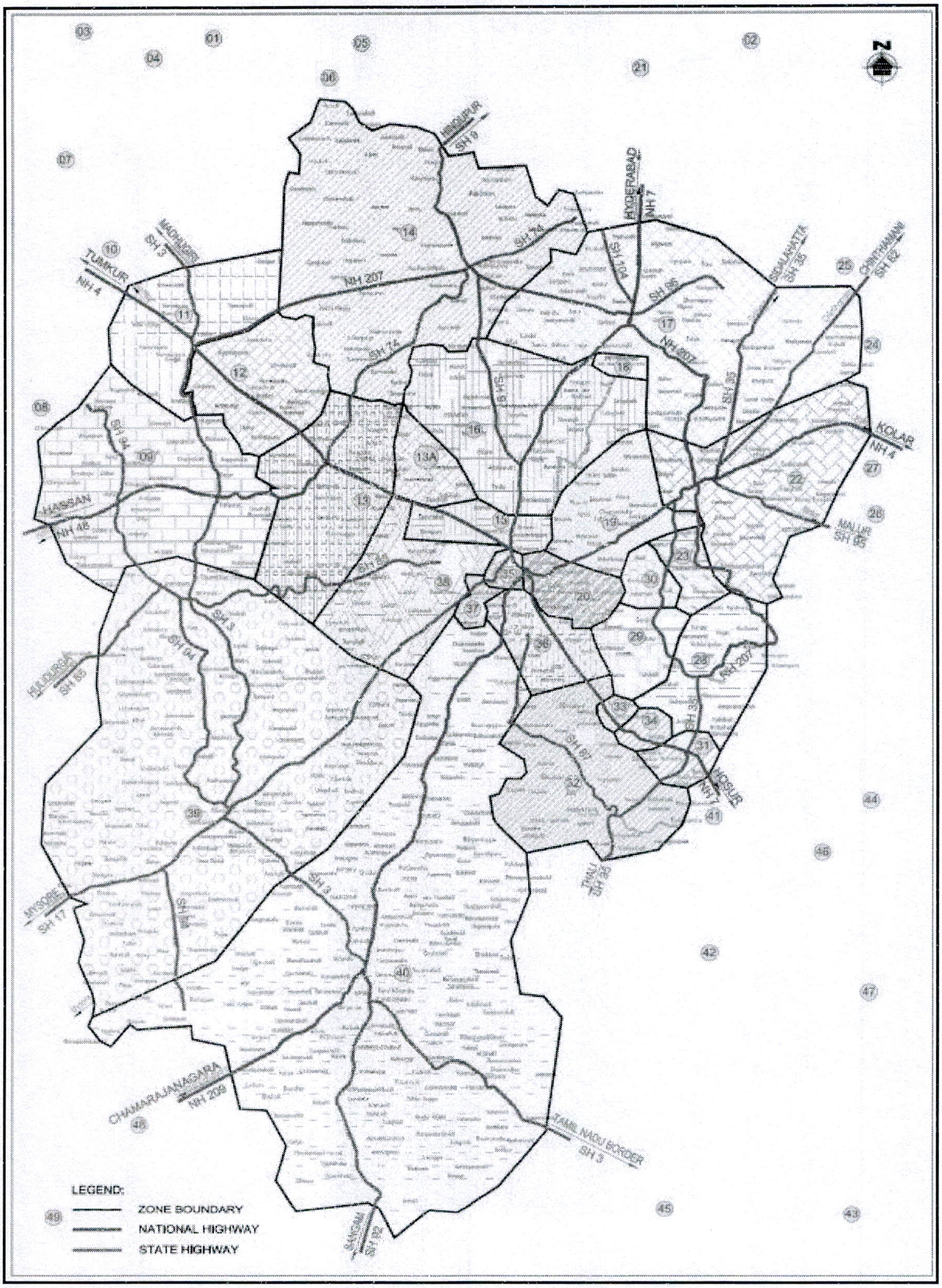
Zone No.	Details of Zones
45	Nilgiris, Dindigul, Teni, Madurai, Virudunagar, Tirunelveli, Nagercoil, Tuticorin, Ramanathapuram, Sivaganga, Namakkal, Tiruchhirapalli, Karur
46	Tiruputtur, Vaniyambadi & Surrounding Areas, Gudiyattam, Pernampet & Surrounding Areas, Walajapet, Ranipet, Tirruvallam, Arcot, Walaja Road, Ammur
47	Tiruvannamali, Vilupuram, Cuddalore, Nagappattinam, Perambalur, Thanjavur, Thiruvarur, Pudukkottai, Pondicherry
48	Kodagu, Chamarajanagar Districts
49	Kerala State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HOSUR
NH 7
THALI
SH 86
TAMIL NADU BORDER
SH 3
SANGAM
SH 92
CHAMARAJANAGARA
NH 209
MYSORE
SH 17
KUDURGA
SH 85
HASSAN
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LEGEND:
ZONE BOUNDARY
NATIONAL HIGHWAY
STATE HIGHWAY

Figure 2-8: OD Zoning Plan

2.7.3 Sample Size

The survey was carried out to capture both personalized and commercial vehicles. Abstract of sample size at various locations are given in Table 2-11.

Table 2-11: Sample Size of OD Survey

	Tumkur Road			Doddaballapura Road			Bellary Road		
Vehicle Type	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**
Passenger Cars	44306	2594	6%	9686	1128	12%	18317	4919	27%
LCV	7768	2034	26%	2233	487	22%	2427	504	21%
Bus	5227	681	13%	1653	283	17%	1737	694	40%
Trucks	10619	4008	38%	1562	386	25%	3664	1577	43%
	Hennur Road			**Old Madras Road**			**Whitefield Road**		
Vehicle Type	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**
Passenger Cars	6333	1001	16%	24525	4315	18%	18446	2204	12%
LCV	1439	601	42%	5830	1094	19%	2481	465	19%
Bus	571	178	31%	4012	1242	31%	1231	188	15%
Trucks	1357	304	22%	6503	1883	29%	2693	670	25%
	Chanasandra Road			**Sarjapura Road**			**Anekal Road**		
Vehicle Type	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**
Passenger Cars	4090	870	21%	12617	1431	11%	6250	1108	18%
LCV	2349	500	21%	1640	334	20%	739	212	29%
Bus	806	61	8%	1324	167	13%	546	185	34%
Trucks	336	38	11%	2468	441	18%	889	175	20%
	Hosur Road								
Vehicle Type	**No of Vehicles per day**	**No of vehicles interviewed**	**% Sample**						
Passenger Cars	22290	4942	22%						
LCV	3144	1067	34%						
Bus	3691	619	17%						
Trucks	11645	2887	25%						

2.7.4 Details from OD Survey

Based on the road side interview survey at important locations, information related to trip purpose for personal and commercial vehicles, loading pattern of commercial vehicles and commodity movements are computed. These are given from Table 2-12 to Table 2-15Table 2-15.

Table 2-12: Distribution of Vehicle Trips – Trip Purpose

Sl	Trip Purpose	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
1	Commercial / Business	26.10%	3.92%	24.20%	6.36%	11.35%	18.84%	25.61%	11.03%	20.55%	6.23%
2	Work / Official	37.07%	19.86%	35.41%	44.83%	35.40%	36.24%	45.91%	54.73%	36.33%	47.37%
3	Personal	18.55%	52.61%	18.73%	45.13%	37.08%	40.38%	24.68%	30.66%	29.22%	39.80%
4	Recreation	3.70%	1.31%	8.20%	0.60%	2.83%	1.98%	1.27%	1.58%	4.13%	0.53%
5	Tourist	11.93%	17.68%	9.91%	2.68%	11.65%	2.38%	2.19%	1.93%	8.09%	5.70%
6	Educational	0.73%	3.83%	0.96%	0.40%	0.90%	0.09%	0.35%	0.07%	0.86%	0.18%
7	Others	1.92%	0.78%	2.59%	0.00%	0.80%	0.09%	0.00%	0.00%	0.82%	0.18%

Table 2-13: Distribution of Vehicle Trips – Frequency

Sl	No of Trips	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
1	One Way Trip	38.88 %	48.78 %	49.14 %	50.30 %	45.05 %	49.80 %	41.60 %	37.99 %	47.28 %	40.60 %
2	Up & Down Trip (within 24 hours)	45.50 %	47.74 %	25.43 %	49.30 %	43.99 %	39.27 %	41.37 %	51.18 %	46.84 %	44.98 %
3	Multiple Trips on same day	5.58%	1.05%	7.20%	0.20%	6.46%	7.15%	3.82%	3.44%	4.45%	8.73%
4	Occasional trips	10.05 %	2.44%	18.23 %	0.20%	4.50%	3.78%	13.21 %	7.38%	1.42%	5.69%

Table 2-14: Distribution of Vehicle Trips - Loading Pattern

Sl	No of Trips	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
1	Once in a day	49.70 %	28.29 %	38.37 %	45.30 %	41.48 %	41.32 %	40.95 %	26.71 %	41.26 %	52.06 %
2	2 or more times in a day	28.50 %	30.01 %	27.40 %	36.91 %	39.03 %	30.04 %	40.96 %	33.93 %	26.13 %	43.30 %

Sl	No of Trips	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
3	Once in 15 days	4.84%	9.28%	5.96%	10.28 %	13.58 %	1.50%	3.02%	8.52%	1.98%	1.55%
4	Once in month	16.96 %	32.42 %	28.27 %	7.51%	5.91%	27.14 %	14.82 %	30.84 %	30.63 %	3.09%
5	Occasional	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%

Table 2-15: Distribution of Vehicle Trips - Commodity Movement

Sl	No of Trips	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
1	Empty	27.84 %	41.81 %	25.66 %	43.65 %	31.30 %	33.60 %	38.56 %	30.05 %	44.95 %	28.73 %
2	Vegetables / Fruit / Milk / Fish	12.88 %	24.74 %	16.82 %	19.79 %	19.21 %	6.88 %	9.80 %	9.94 %	10.08 %	7.89 %
3	Food Grains	5.11 %	9.05 %	10.19 %	9.83 %	5.41 %	11.73 %	5.53 %	20.13 %	14.99 %	7.84 %
4	Salt	3.77 %	6.07 %	6.44 %	2.54 %	9.54 %	3.44 %	3.52 %	1.03 %	1.03 %	3.72 %
5	Building Materials	8.90 %	12.71 %	13.70 %	22.32 %	13.27 %	18.78 %	21.98 %	18.45 %	11.11 %	19.30 %
6	Wood	6.72 %	1.95 %	3.41 %	0.88 %	3.12 %	7.41 %	7.66 %	4.52 %	3.62 %	4.25 %
7	Textile Materials	3.24 %	1.49 %	2.31 %	0.22 %	1.88 %	2.65 %	1.38 %	3.61 %	3.36 %	2.00 %
8	Leather	1.36 %	0.00 %	0.67 %	0.00 %	0.84 %	0.26 %	0.88 %	1.68 %	1.29 %	1.29 %
9	Plastic Products	2.37 %	0.69 %	1.49 %	0.11 %	0.37 %	0.71 %	0.88 %	5.42 %	2.33 %	3.82 %
10	Iron coils/pipes/cables/wire	4.95 %	1.26 %	2.98 %	0.66 %	0.81 %	3.26 %	2.01 %	2.06 %	5.94 %	3.92 %
11	Minerals	1.42 %	0.00 %	2.88 %	0.00 %	1.11 %	0.35 %	0.25 %	0.90 %	0.00 %	2.73 %
12	Petrol / diesel / Gas / LPG	2.43 %	0.00 %	3.51 %	0.00 %	6.48 %	0.71 %	0.63 %	0.52 %	0.00 %	2.58 %
13	Fertilizer	1.16 %	0.00 %	0.00 %	0.00 %	0.13 %	0.00 %	0.00 %	0.26 %	0.00 %	0.46 %
14	Finished Consumer Goods	1.08 %	0.00 %	0.24 %	0.00 %	0.77 %	0.26 %	0.13 %	0.13 %	0.00 %	0.15 %
15	Paint / Dyes	0.91 %	0.00 %	2.11 %	0.00 %	1.44 %	0.00 %	0.25 %	0.26 %	0.00 %	1.67 %
16	Machine	1.74 %	0.00 %	2.50 %	0.00 %	0.81 %	0.26 %	1.76 %	0.13 %	0.52 %	1.85 %
17	Container	6.87 %	0.00 %	1.11 %	0.00 %	1.55 %	3.44 %	1.63 %	0.13 %	0.00 %	2.43 %
18	Aluminium	0.45 %	0.00 %	1.01 %	0.00 %	0.00 %	0.44 %	0.25 %	0.00 %	0.26 %	0.66 %
19	Chemicals	1.01	0.00	0.19	0.00	0.24	0.18	0.13	0.13	0.00	0.38

SI	No of Trips	Tumkur Road	Dodaballapur Road	Bellary Road	Hennur Road	Old Madras Road	Whitefield Road	Chanasandra Road	Sarjapura Road	Anekal Road	Hosur Road
		%	%	%	%	%	%	%	%	%	%
20	Liquid Oxygen	1.22 %	0.00 %	1.92 %	0.00 %	0.07 %	2.91 %	2.14 %	0.26 %	0.00 %	2.18 %
21	Others	4.57 %	0.23 %	0.86 %	0.00 %	1.65 %	2.73 %	0.63 %	0.39 %	0.52 %	2.15 %

2.7.5 Desire Line Diagram

The origin destination details collected during the survey was on sample basis w,r,t total traffic movement during the day of the survey. Hence, it is necessary to raise / increase the proportion to reflect the total vehicle trips during the day. Hence expansion factors are calculated for each vehicular class.

The collected data during the survey has been grouped according to the zones mentioned above. With this predefined zones, the origin-destination matrices have been prepared for individual type of vehicles for all locations of survey.

In order to assess the influence of each zone on its traffic attraction and production of trips, the influence factors have been calculated for each vehicle type. Influence factor indicates the importance of the zone in the study area. The details of influence factors for all the vehicle types are given in Table 2-16.

Desire line diagrams for various categories of vehicles are given from Figure 2-9 to Figure 2-13.

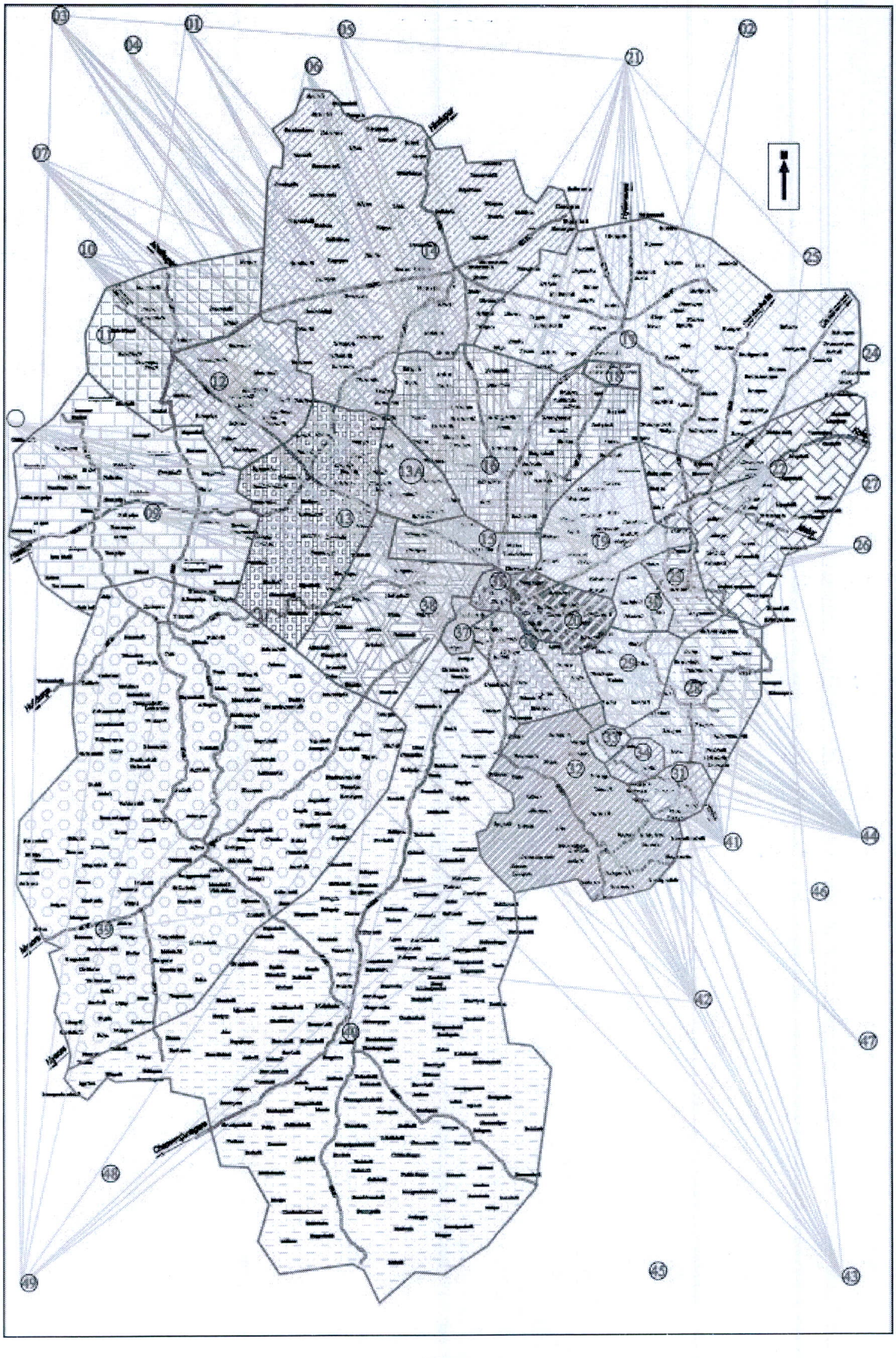
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Figure 2-9: Desire Line Diagram for 2 Axle Truck

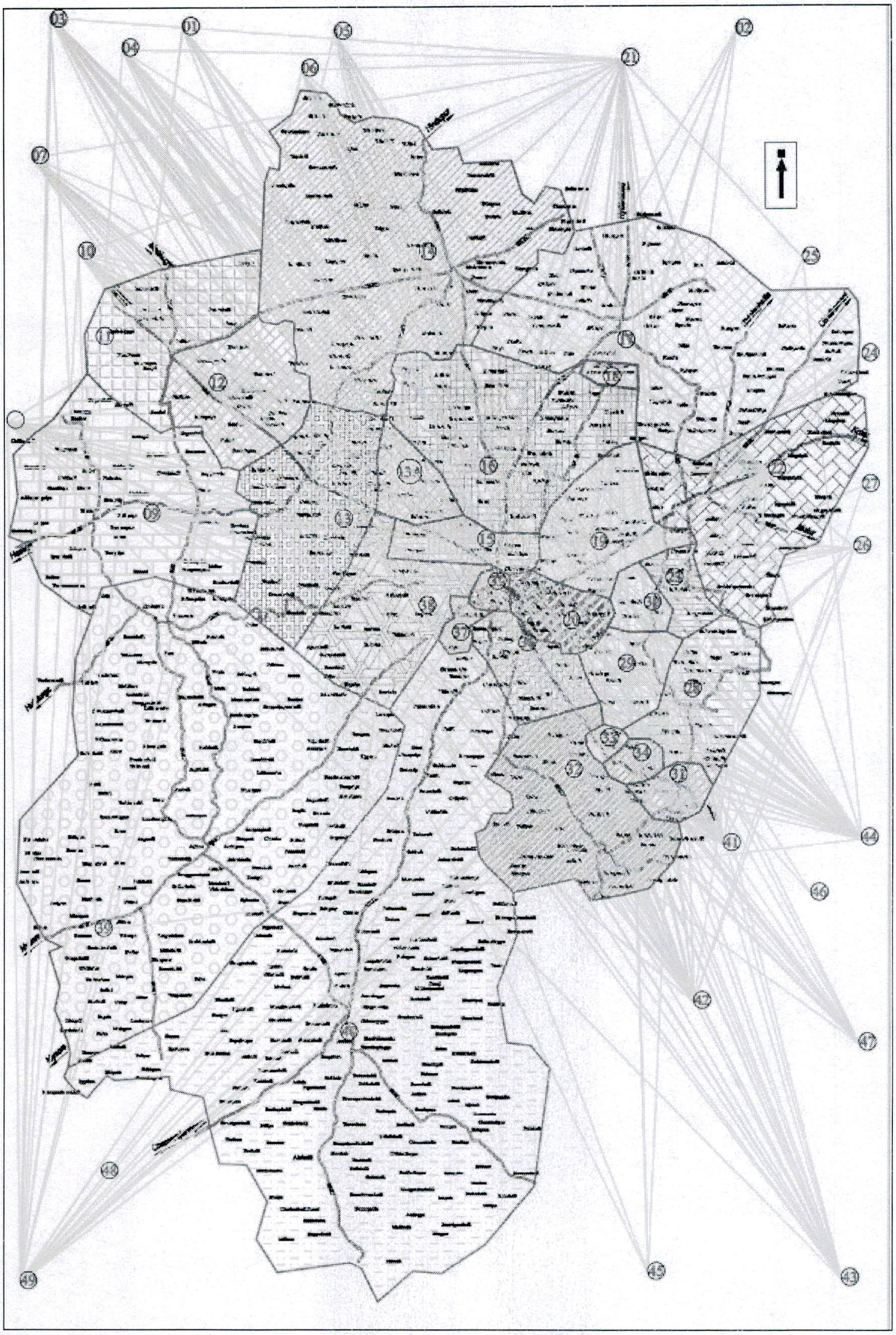
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Figure 2-10: Desire Line Diagram for 3 Axle Truck

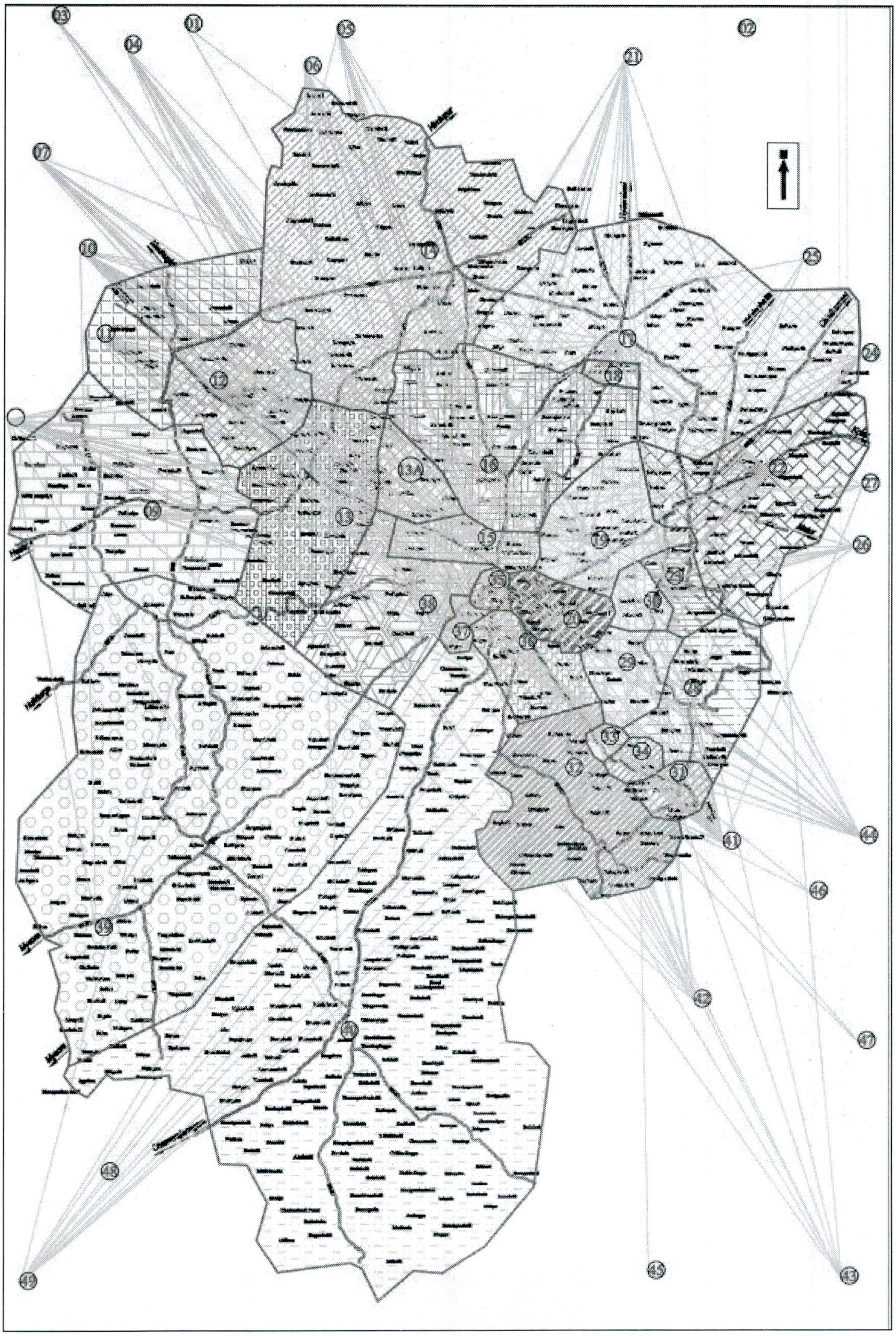
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Figure 2-11: Desire Line Diagram for Car (yellow)

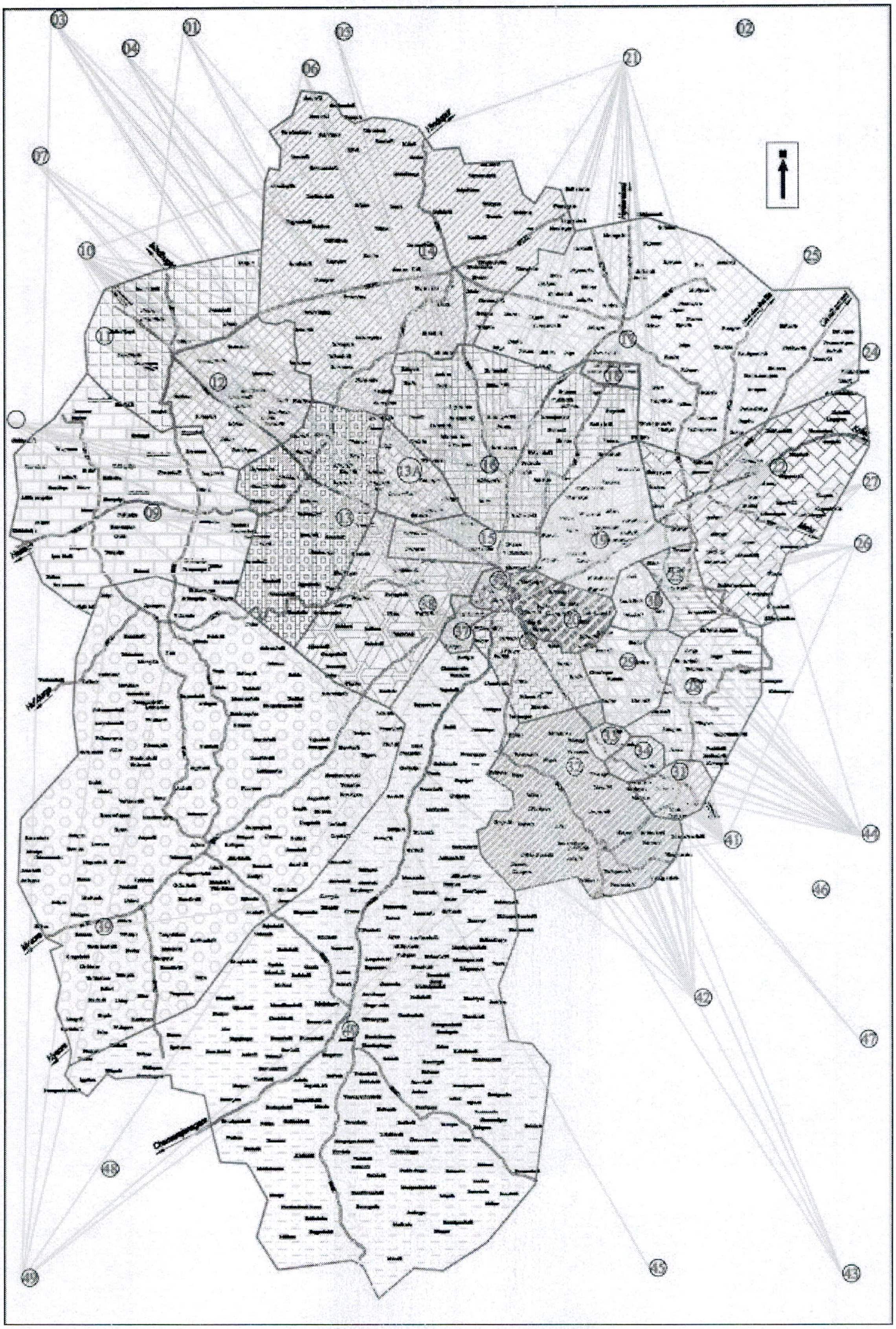
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Figure 2-12: Desire Line Diagram for LCV

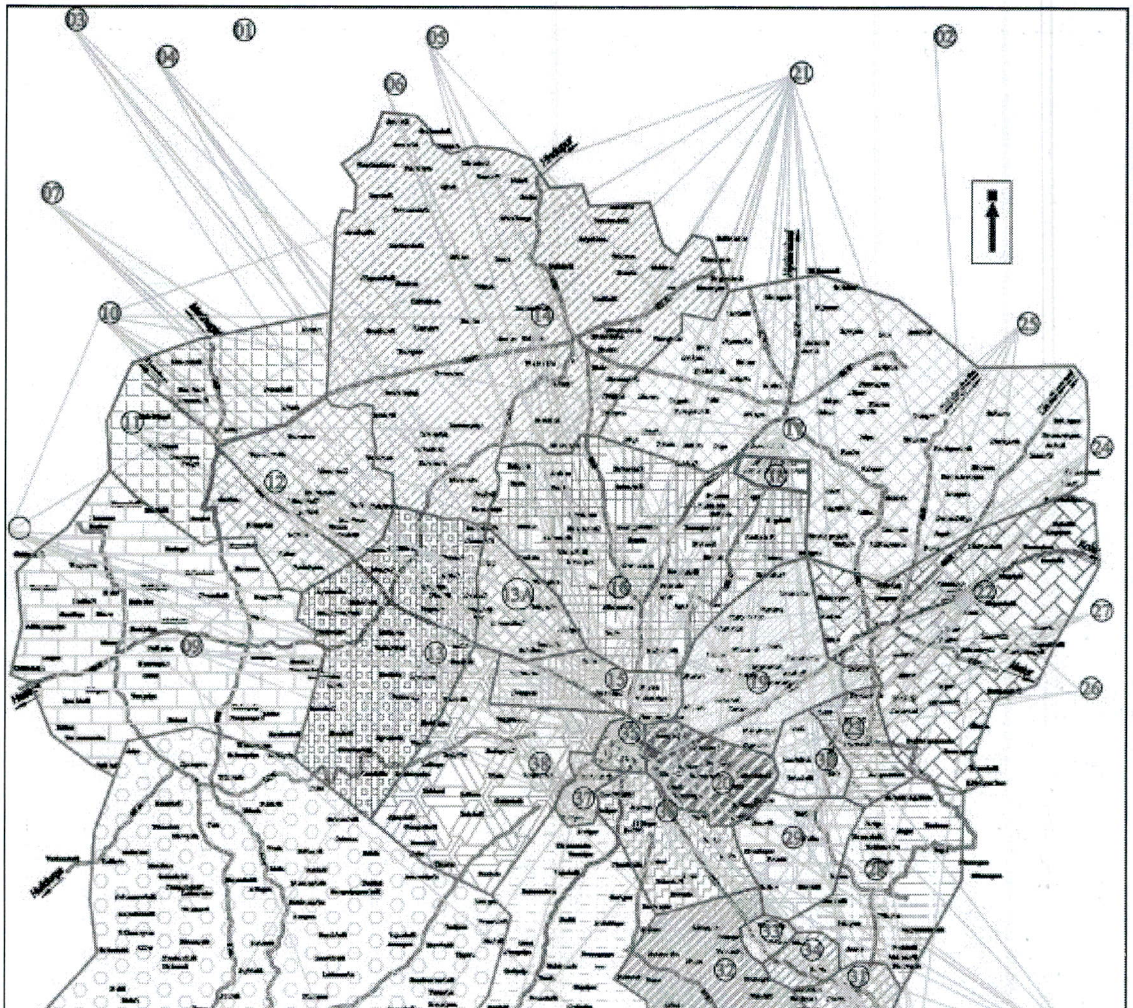
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Figure 2-13: Desire Line Diagram for Bus

2.7.6 Influence Factors

In order to assess the influence of each zone on its traffic attraction and production of trips, the influence factors have been calculated for each vehicle type. Influence factor indicates the importance of the zone in the study area. The details of influence factors for all the vehicle types are worked out and the summary is given in Table 2-16.

Table 2-16: Influence Factors from OD

Tumkur Road				
	Car	Bus	LCV	Trucks
N / NE India	0.01%	0.04%	0.78%	3.26%
West India	0.62%	1.14%	2.98%	11.16%
AP & Telangana	0.92%	1.38%	1.15%	1.06%
Tamil Nadu	0.79%	1.19%	3.42%	11.07%
Kerala	0.12%	0.08%	0.59%	1.67%
Bangalore	58.60%	62.13%	66.60%	45.23%
Rest of Karnataka	38.94%	34.04%	24.48%	26.54%
Total	100%	100%	100%	100%

Doddaballapur Road				
	Car	Bus	LCV	Trucks
N / NE India	0.00%	0.00%	0.00%	0.00%
West India	0.00%	0.00%	0.06%	0.00%
AP & Telangana	7.33%	2.00%	10.56%	19.06%
Tamil Nadu	2.07%	0.10%	1.66%	4.13%
Kerala	0.09%	0.00%	0.00%	0.00%
Bangalore	85.09%	96.86%	77.94%	61.63%
Rest of Karnataka	5.41%	1.05%	9.79%	15.18%
Total	100%	100%	100%	100%

Bellary Road				
	Car	Bus	LCV	Trucks
N / NE India	0.08%	0.08%	0.20%	0.84%
West India	0.09%	0.04%	0.21%	0.17%
AP & Telangana	21.41%	16.82%	25.85%	30.32%
Tamil Nadu	1.35%	0.87%	1.71%	2.06%
Kerala	0.25%	0.45%	0.13%	0.08%
Bangalore	71.94%	77.48%	69.25%	63.86%
Rest of Karnataka	4.88%	4.26%	2.64%	2.66%
Total	100%	100%	100%	100%

Hennur Road				
	Car	Bus	LCV	Trucks
N / NE India	0.00%	0.00%	0.00%	0.00%
West India	0.00%	0.00%	0.12%	0.00%
AP & Telangana	1.33%	0.44%	4.99%	8.63%
Tamil Nadu	0.52%	0.00%	1.31%	1.35%
Kerala	0.00%	0.00%	0.00%	0.00%
Bangalore	97.36%	99.56%	92.33%	85.27%
Rest of Karnataka	0.79%	0.00%	1.24%	4.74%
Total	100%	100%	100%	100%

Old Madras Road				
	Car	Bus	LCV	Trucks
N / NE India	0.00%	0.00%	0.08%	0.08%
West India	0.06%	0.00%	0.00%	0.03%
AP & Telangana	12.87%	8.28%	11.07%	19.82%
Tamil Nadu	14.16%	18.66%	1.76%	6.27%
Kerala	0.51%	1.76%	0.31%	0.11%
Bangalore	69.23%	68.19%	78.71%	58.67%
Rest of Karnataka	3.16%	3.11%	8.07%	15.02%

Whitefield Road				
	Car	Bus	LCV	Trucks
N / NE India	0.00%	0.00%	0.07%	0.03%
West India	0.01%	0.00%	0.19%	0.32%
AP & Telangana	2.67%	0.73%	7.39%	23.95%
Tamil Nadu	4.63%	0.35%	9.49%	8.33%
Kerala	0.15%	0.56%	0.00%	0.00%
Bangalore	92.07%	98.36%	81.53%	53.64%
Rest of Karnataka	0.46%	0.00%	1.33%	13.73%

Total	100%	100%	100%	100%

Total	100%	100%	100%	100%

Channasandra Road				
	Car	**Bus**	**LCV**	**Trucks**
N / NE India	0.00%	0.00%	0.23%	0.00%
West India	0.06%	0.00%	0.00%	0.00%
AP & Telangana	0.68%	0.00%	0.63%	0.61%
Tamil Nadu	11.16%	5.74%	15.90%	16.25%
Kerala	0.00%	0.00%	0.00%	0.00%
Bangalore	88.03%	93.44%	83.08%	83.00%
Rest of Karnataka	0.08%	0.82%	0.16%	0.14%
Total	100%	100%	100%	100%

Sarjapura Road				
	Car	**Bus**	**LCV**	**Trucks**
N / NE India	0.00%	0.00%	0.00%	0.00%
West India	0.00%	0.00%	0.00%	0.00%
AP & Telangana	1.83%	0.00%	0.20%	0.50%
Tamil Nadu	21.86%	2.91%	23.46%	22.90%
Kerala	0.43%	0.00%	0.00%	0.00%
Bangalore	75.52%	97.09%	74.22%	75.91%
Rest of Karnataka	0.36%	0.00%	2.11%	0.69%
Total	100%	100%	100%	100%

Anekal Road				
	Car	**Bus**	**LCV**	**Trucks**
N / NE India	0.00%	0.00%	0.00%	0.00%
West India	0.49%	0.15%	0.14%	0.00%
AP & Telangana	0.06%	0.00%	0.43%	0.17%
Tamil Nadu	14.92%	14.66%	12.22%	12.48%
Kerala	0.00%	0.00%	0.00%	0.00%
Bangalore	82.59%	82.79%	84.08%	85.32%
Rest of Karnataka	1.94%	2.40%	3.12%	2.03%
Total	100%	100%	100%	100%

Hosur Road				
	Car	**Bus**	**LCV**	**Trucks**
N / NE India	0.00%	0.00%	2.09%	2.60%
West India	0.10%	0.00%	1.23%	4.30%
AP & Telangana	0.44%	0.52%	0.67%	1.03%
Tamil Nadu	46.88%	47.87%	48.37%	48.30%
Kerala	2.85%	2.08%	1.36%	1.44%
Bangalore	42.66%	47.54%	41.55%	35.64%
Rest of Karnataka	7.07%	1.99%	4.72%	6.69%
Total	100%	100%	100%	100%

Following can be inferred:

- Influence of Karnataka in origin and destination of all classes of vehicles are very significant at all locations except at Hosur road.
- Due to close proximity to Tamilnadu on southern side, influence of Tamilnadu is seen at Hosur road.
- Influence of Andhra Pradesh as major attraction zone is seen on Doddaballapur and Bellary side as they link to AP beyond Karnataka.

2.7.7 Traffic Assignment on Project Road

The proposed PRR is on the outskirts of the city at a radial distance varying between 17 Km to 25 Km. Hence the traffic pattern on the proposed road is influenced by following two factors:

- Diverted traffic from major radial roads intersecting PRR like Tumkur road on west, Dodaballaupur road on North-West, Bellary road on North, Hennur road on North-East, Old Madras road on East, Whitefield road, Hosakote - Anekal road and Bangalore - Sarjapur road on South-West and Hosur road on South.
- Traffic likely to be generated due to developments of area as per BDA's Master Plan between existing Outer Ring Road and PRR, around and beyond PRR.
- Existing NICE road connecting Tumkur Road on west and Hosur road on south (~ 44 Km) which is used by commercial vehicles without entering the city.
- NH-207 (Dabaspete – Doddaballapur – Hosakote) provides direct connectivity between Tumkur road on west and Bellary road on north and Old Madras road on east. Commercial and passenger traffic would use this road rather than passing through PRR.

2.7.8 Summary of Number Plate Survey

Number Plate survey is conducted at existing National Highways for a period of 24 hours on a wording day. The survey comprised of noting down:

- Registration numbers of all commercial vehicles along with permit status (National Permit / Non National Permit).
- Registration numbers of all passenger vehicles passing though the stretch.

Proportion of passenger vehicles with local registration is given in **Table 2-17**.

Table 2-17: Passenger Vehicles with Local Registration

Vehicles	Passenger Car (White)	Passenger Car (Yellow)	LCV - Passenger
Tumkur Road	73.84%	72.73%	75.71%
Dodaballapur Road	83.73%	78.18%	81.08%
Bellary Road	72.66%	81.25%	78.41%
Hennur Road	87.23%	88.81%	70.00%
Old Madras Road	76.24%	80.31%	75.84%
Whitefield Road	81.33%	78.70%	82.98%
Channasandra Road	88.72%	84.88%	84.78%
Sarjapura Road	84.51%	84.69%	81.65%
Anekal Road	84.65%	85.67%	88.89%
Hosur Road	55.81%	66.77%	63.57%

Proportion of commercial vehicles with local registration and without National Permit is given in Table 2-18.

Table 2-18: Non NP Commercial Vehicles with Local Registration

Vehicles	Bus	LCV - Goods	2 Axle Truck	3 Axle Truck	Multi Axle Truck
Tumkur Road	48.59%	57.76%	44.82%	34.85%	38.06%
Dodaballapur Road	61.94%	75.26%	74.16%	66.67%	63.21%
Bellary Road	58.70%	68.36%	64.33%	51.89%	43.26%
Hennur Road	67.95%	75.23%	75.56%	78.86%	75.42%
Old Madras Road	56.14%	67.00%	57.76%	57.85%	46.54%
Whitefield Road	69.17%	73.79%	71.03%	71.97%	63.05%
Channasandra Road	83.44%	76.88%	64.88%	71.72%	67.29%
Sarjapura Road	69.62%	76.28%	72.43%	74.21%	40.87%
Anekal Road	69.29%	75.25%	75.60%	77.57%	30.00%
Hosur Road	47.66%	48.82%	37.71%	40.53%	21.11%

2.7.9 Break up of Toll type

Trip details are collected during Origin Destination surveys. The details obtained from the survey are categorised to compute tollable vehicles making single trips, return trips, vehicles preferring monthly passes at 4 locations. Summary of toll details are compiled section-wise and presented in Table 2-19.

Table 2-19: Summary of Toll Details

Toll Trip Particulars	**Section-1**			
	Single	**Return**	**Monthly**	**Exempted**
Passenger Cars (Pvt)	56%	32%	9%	3%
Passenger Cars (Taxi)	56%	32%	9%	3%
LCV (Passenger)	63%	25%	10%	2%
LCV (Goods)	64%	26%	8%	2%
Mini Bus	36%	57%	7%	0%
Bus	57%	38%	5%	0%
2 Axle Trucks	71%	17%	10%	2%

3 Axle Trucks	72%	16%	10%	2%
MAV and OSV	78%	11%	9%	2%
Toll Trip Particulars	Section-2			
	Single	Return	Monthly	Exempted
Passenger Cars (Pvt)	57%	30%	9%	4%
Passenger Cars (Taxi)	57%	30%	10%	3%
LCV (Passenger)	85%	13%	0%	2%
LCV (Goods)	65%	21%	12%	2%
Mini Bus	32%	68%	0%	0%
Bus	49%	47%	4%	0%
2 Axle Trucks	62%	21%	14%	3%
3 Axle Trucks	67%	14%	16%	3%
MAV and OSV	68%	15%	16%	1%
Toll Trip Particulars	**Section-3**			
	Single	**Return**	**Monthly**	**Exempted**
Passenger Cars (Pvt)	63%	24%	10%	3%
Passenger Cars (Taxi)	58%	29%	10%	3%
LCV (Passenger)	66%	29%	4%	1%
LCV (Goods)	76%	18%	5%	1%
Mini Bus	63%	37%	0%	0%
Bus	44%	50%	6%	0%
2 Axle Trucks	78%	13%	7%	2%
3 Axle Trucks	84%	11%	4%	1%
MAV and OSV	88%	4%	7%	1%

2.7.10 Origin Destination Pattern

Based on the OD surveys, commercial and passenger traffic are assigned to various zones of their origin and destinations. Traffic likely to ply on PRR, either for full stretch or for part length is summarised in Table 2-20.

Table 2-20: Contributing OD Zones for PRR Traffic

Origin	Code	Destination	Origin Code	Destination Code
Tumkur Road - A	A	Tumkur Road	-	-
	B	Hesaraghatta Road	1 to 12,15,38,39,40,48,49	13
	C	Doddaballapur Road	1 to 12,15,38,39,40,48,49	14,21
	D	Bellary Road	1 to 4,7 to 12,15,38,39,40,48,49	5,6,16,17,18,21
	E	Hennur Road	1 to 12,15,38,39,40,48,49	19,20
	F	Old Madras Road	1 to 12,15	22,24,25,26
	G	Whitefield Road	1 to 12,15	27,30
	H	Channasandra Road	1 to 12,15	23
	I	Hosakote-Sarjapur Road	1 to 12,15	29
	J	B'lore-Sarjapur Road	1 to 12,15	28
	K	Hosur Road	1 to 12,15	31 to 34, 41 to 47
Hesaraghatta Road - B	A	Tumkur Road	13	1 to 4,7 to 12,15,38,39,40,48,49
	B	Hesaraghatta Road	-	-
	C	Doddaballapur Road	13	14,21
	D	Bellary Road	13	5,6,16,17,18,21
	E	Hennur Road	13	19,20
	F	Old Madras Road	13	22,24,25,26
	G	Whitefield Road	13	27,30
	H	Channasandra Road	13	23
	I	Hosakote-Sarjapur Road	13	29
	J	B'lore-Sarjapur Road	13	28
	K	Hosur Road	13	31 to 34, 41 to 47
Doddaballapur Road - C	A	Tumkur Road	14,21	1 to 12
	B	Hesaraghatta Road	14,21	13
	C	Doddaballapur Road	-	-
	D	Bellary Road	14,21	16,17,18,21
	E	Hennur Road	14,21	19,20
	F	Old Madras Road	14,21	22,25,26

Origin	Code	Destination	Origin Code	Destination Code
		Road		
	K	Hosur Road	29	31 to 34, 41 to 47
B'lore-Anekal Road - J	A	Tumkur Road	28	1 to 4, 7 to 12
	B	Hesaraghatta Road	28	13
	C	Doddaballapur Road	28	14,15,21
	D	Bellary Road	28	5,6,16,17,18,21
	E	Hennur Road	28	19,20
	F	Old Madras Road	28	22,24,25,26
	G	Whitefield Road	28	27,30
	H	Channasandra Road	28	23
	I	Hosakote-Sarjapur Road	28	29
	J	B'lore-Sarjapur Road	-	-
	K	Hosur Road	28	31 to 34, 41 to 47
Hosur Road - K	A	Tumkur Road	31 to 34,36,41 to 47	1 to 4, 7 to 12
	B	Hesaraghatta Road	31 to 34,36,41 to 47	13
	C	Doddaballapur Road	31 to 34,36,41 to 47	14,15,21
	D	Bellary Road	31 to 34,36,41 to 47	5,6,16,17,18,21
	E	Hennur Road	31 to 34,36,41 to 47	19,20
	F	Old Madras Road	31 to 34,36,41 to 47	22,24,25,26
	G	Whitefield Road	31 to 34,36,41 to 47	27,30
	H	Channasandra Road	31 to 34,36,41 to 47	23
	I	Hosakote-Sarjapur Road	31 to 34,36,41 to 47	29
	J	B'lore-Sarjapur Road	31 to 34,36,41 to 47	28
	K	Hosur Road	-	-

2.8 Traffic Assignment on PRR

Proposed traffic likely to get diverted from existing major roads are worked out based on OD pattern. The proposed road will have entry / exit points at 10 locations (only entry at Hessaraghatta towards Hosur) and toll plazas will be located at each entry and exit points. Traffic entering at various origin points are assigned to destination and OD matrix is developed. This will be the "Base Diverted Traffic Stream".

2.9 Considerations

The proposed PRR alignment will be at a radial distance of 17 to 22 Km from Bangalore city. It is expected that long distance personalised traffic and commercial vehicles plying on National and State highways will get diverted onto PRR instead of passing through existing

Outer Ring Road which is already congested and has become part of city road. There are other agencies which are either planning / implementing other road developments which may have bearing on the PRR traffic. These are reviewed in following sections.

2.9.1 Existing NICE Road

All commercial (truck) traffic between Hosur road and Tumkur road use existing NICE road between Tumkur road and Hosur road. The NICE road alignment from Madanayakanahalli to Electronic city is ~ 44 Km long crosses Magadi road, Mysore road, Kanakapura road, Bannerghatta road. NICE road is divided 4 lane road without service road. In addition to truck traffic, passenger car traffic having destination on south / south-west part of Bangalore city uses this road. This is in addition to existing ORR between Gorguntepalya junction and CSB junction. Hence, in the traffic assignment this prevailing traffic movement is considered.

2.9.2 Effect of NH-207

National Highway Authority of India (NHAI) is implementing widening of existing 2 lane road to 4 lane facility between Dabaspete and Hosakote section of NH-207. Start point of NH 207 is located at a distance of ~ 32Km from PRR on Tumkur road end and ~ 6 Km on Old Madras Road end (ref Figure 2-14). Following are inferred:

- the distance travelled between same points on Tumkur road and Old Madras road are generally the same (81 Km via NH-207 and 79 Km via PRR).
- PRR is proposed to be completely access controlled facility for main road traffic with access to entry / exit main road at only 4 points excluding termination points. Whereas, NH 207 is proposed to be partially access controlled facility.
- NH-207 is proposed with bypasses for ~ 50% of the total length of the project and hence local interference will also be substantially less for main road traffic.
- Hence, in the analysis, traffic between Tumkur and Old Madras Road direction is assumed to use NH-207 instead of travelling on PRR.

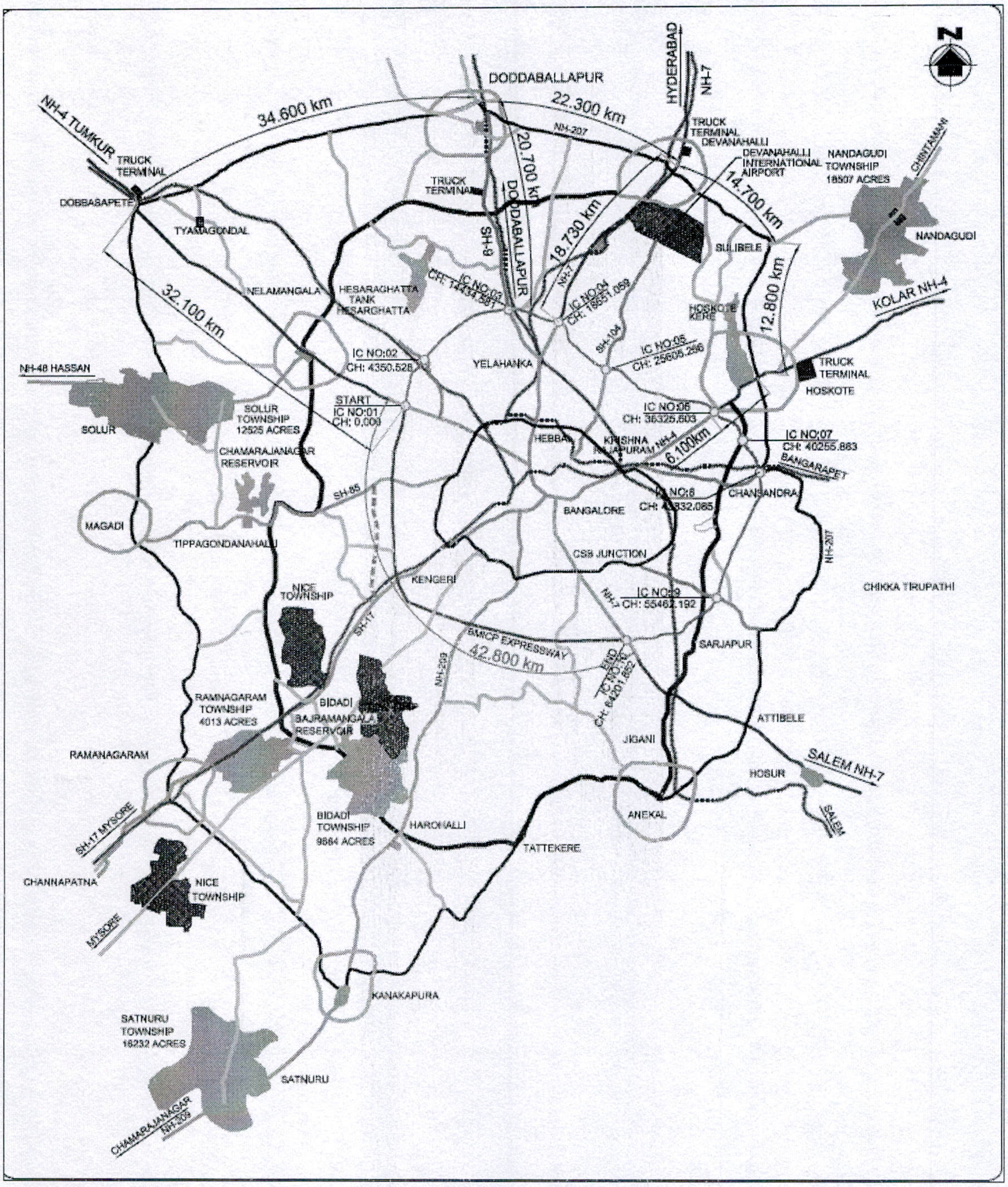
N
DODDABALLAPUR
HYDERABAD
NH-7
NH-4 TUMKUR
34.600 km
22.300 km
NH-207
TRUCK TERMINAL
DOBBASAPETE
TRUCK TERMINAL DEVANAHALLI
DEVANAHALLI INTERNATIONAL AIRPORT
NANDAGUDI TOWNSHIP 18507 ACRES
CHINTAMANI
NANDAGUDI
TRUCK TERMINAL
20.700 km
14.700 km
TYAMAGONDAL
SH-9
DODDABALLAPUR
18.730 km
SULIBELE
12.800 km
NH-7
32.100 km
NELAMANGALA
HESARAGHATTA TANK
HESARGHATTA
IC NO:03 CH: 14434.581
IC NO:04 CH: 18551.059
HOSKOTE KERE
KOLAR NH-4
SH-104
IC NO:02 CH: 4350.528
YELAHANKA
IC NO:05 CH: 25605.256
TRUCK TERMINAL
HOSKOTE
NH-48 HASSAN
START IC NO:01 CH: 0.000
SOLUR TOWNSHIP 12525 ACRES
SOLUR
IC NO:06 CH: 36325.603
HEBBAL
KRISHNA RAJAPURAM
NH-4
6.100km
IC NO:07 CH: 40255.863
BANGARAPET
CHAMARAJANAGAR RESERVOIR
SH-85
IC NO:8 CH: 42332.065
CHANSANDRA
BANGALORE
MAGADI
TIPPAGONDANAHALLI
CSB JUNCTION
NH-207
KENGERI
NICE TOWNSHIP
IC NO:9 CH: 55462.192
CHIKKA TIRUPATHI
NH-7
SH-17
BMICP EXPRESSWAY
42.800 km
SARJAPUR
END IC NO:10 CH: 64201.862
NH-209
RAMNAGARAM TOWNSHIP 4013 ACRES
BIDADI
BAJRAMANGALA RESERVOIR
ATTIBELE
JIGANI
RAMANAGARAM
SALEM NH-7
HOSUR
SH-17 MYSORE
BIDADI TOWNSHIP 9864 ACRES
HAROHALLI
ANEKAL
SALEM
TATTEKERE
CHANNAPATNA
NICE TOWNSHIP
MYSORE
KANAKAPURA
SATNURU TOWNSHIP 16232 ACRES
SATNURU
CHAMARAJANAGAR NH-209

Figure 2-14: Key Plan showing PRR along with NH-207

2.10 Generated Traffic

On completion of Peripheral ring road between Tumkur road and Hosur road, the area between existing ORR and PRR, and area beyond PRR will generate traffic on account of development of layouts by both private and Government agencies. Comprehensive Development Plan for the city of Bangalore has identified various development mix in and around Bangalore city. Key Plan showing various planning districts through which PRR pass is given in Figure 2-15.

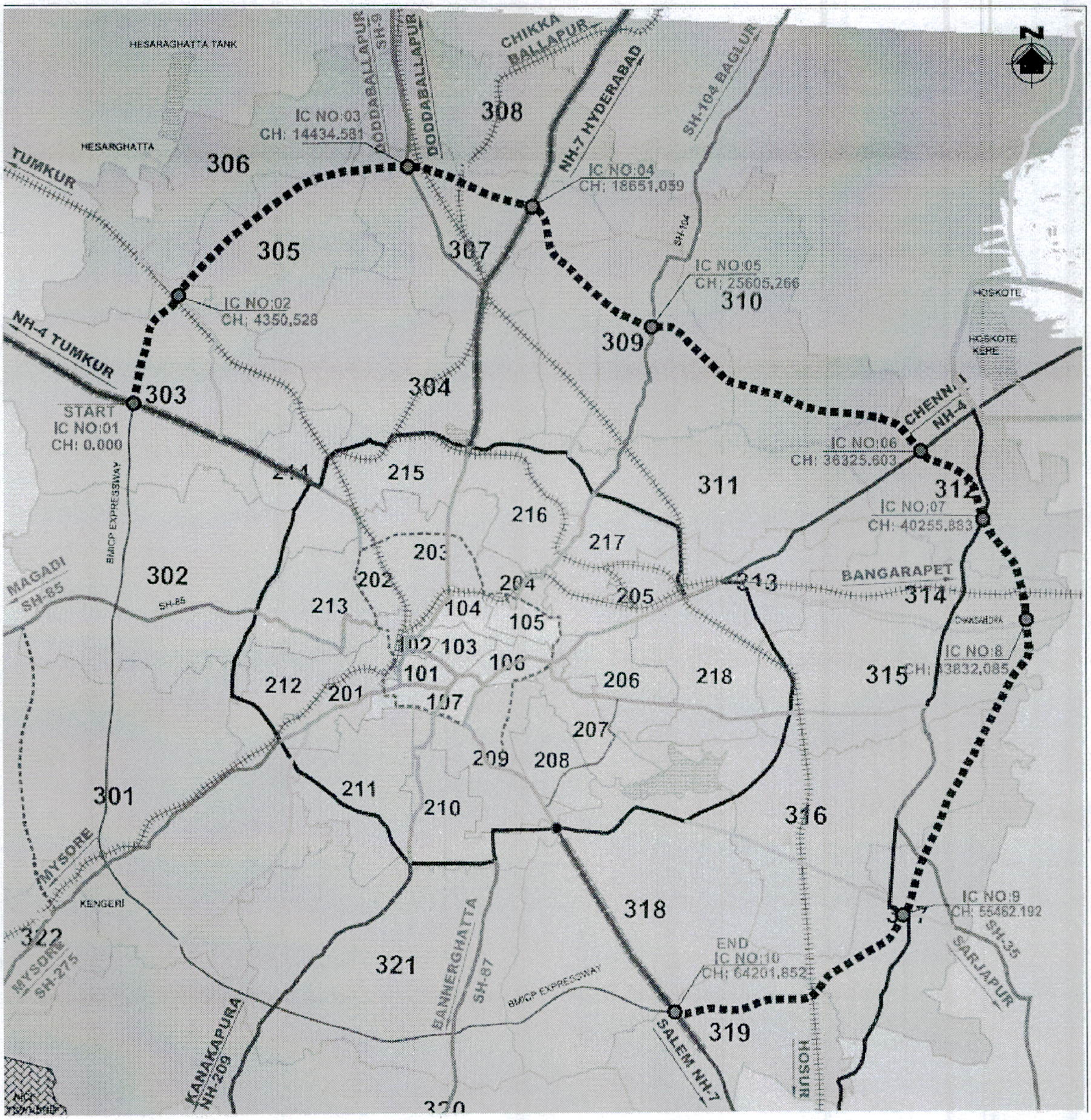
N
HESARAGHATTA TANK
HESARGHATTA
TUMKUR
NH-4 TUMKUR
DODDABALLAPUR SH-9
DODDABALLAPUR
CHIKKA BALLAPUR
NH-7 HYDERABAD
SH-104 BAGLUR
SH-104
IC NO:03 CH: 14434.581
IC NO:04 CH: 18651.059
IC NO:05 CH: 25605.266
IC NO:02 CH: 4350.528
START IC NO:01 CH: 0.000
IC NO:06 CH: 36325.603
IC NO:07 CH: 40255.883
IC NO:8 CH: 43832.085
IC NO:9 CH: 55462.192
END IC NO:10 CH: 64201.852
CHENNAI NH-4
HOSKOTE
HOSKOTE KERE
BANGARAPET
MAGADI SH-85
SH-85
BMICP EXPRESSWAY
MYSORE
KENGERI
MYSORE SH-275
KANAKAPURA NH-209
BANNERGHATTA SH-87
SALEM NH-7
HOSUR
SH-35 SARJAPUR
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Figure 2-15: Key Plan showing various planning districts through which PRR pass

Traffic generated on account of development of various layouts from planning districts are worked out based on following parameters and assumptions given in Comprehensive Traffic and Transportation Plan for Bangalore.

- Per Capita Trip Rate of 0.924 is used as given in Table 3.11 of CTTP.
- Existing travel pattern split as per Table 3.2 of CTTP will be Bus (45.72%), Rail Transport (0%), Car (7.22%), T/w (32.03%), IPT (12.61%) and Cycle (2.4%).

- Proposed travel pattern split as per Table 6.6 of CTTP will be Public Transport (bus/ metro) (69.8%, T/w (18.7%), Auto (8.1%) and Car (3.5%)
- Passenger Car Unit equivalent for various vehicles are used as given in Table 4.3 of CTTP.
- Occupancy rate of vehicles as per Table 4.3 of CTTP are car (8), Bus (55), T/w (1.53), Car (2.59), Bicycle (1), Auto (3), Mini Van (25), LCV (3) and Truck (3) are used.
- Of the total generated traffic, buses, t/w auto, bicycles and some proportion of cars will use service road.
- Out of total generated traffic, only 50% of the traffic is assumed to ply along PRR while remaining traffic will continue to use existing radial roads and outer ring road to reach various parts of the city.

Since the distance of proposed Peripheral ring road is just around 15 Km from the city (5-7 Km from ORR), the entire area beyond existing Outer ring road upto and beyond proposed PRR has developed with residential layouts, educational institutions and few commercial developments all along. BDA, as part of their master plan is also intending to develop various layouts around the city as per details given in Figure 2-16. The traffic likely to be generated on account of layouts are slow moving and car traffic.

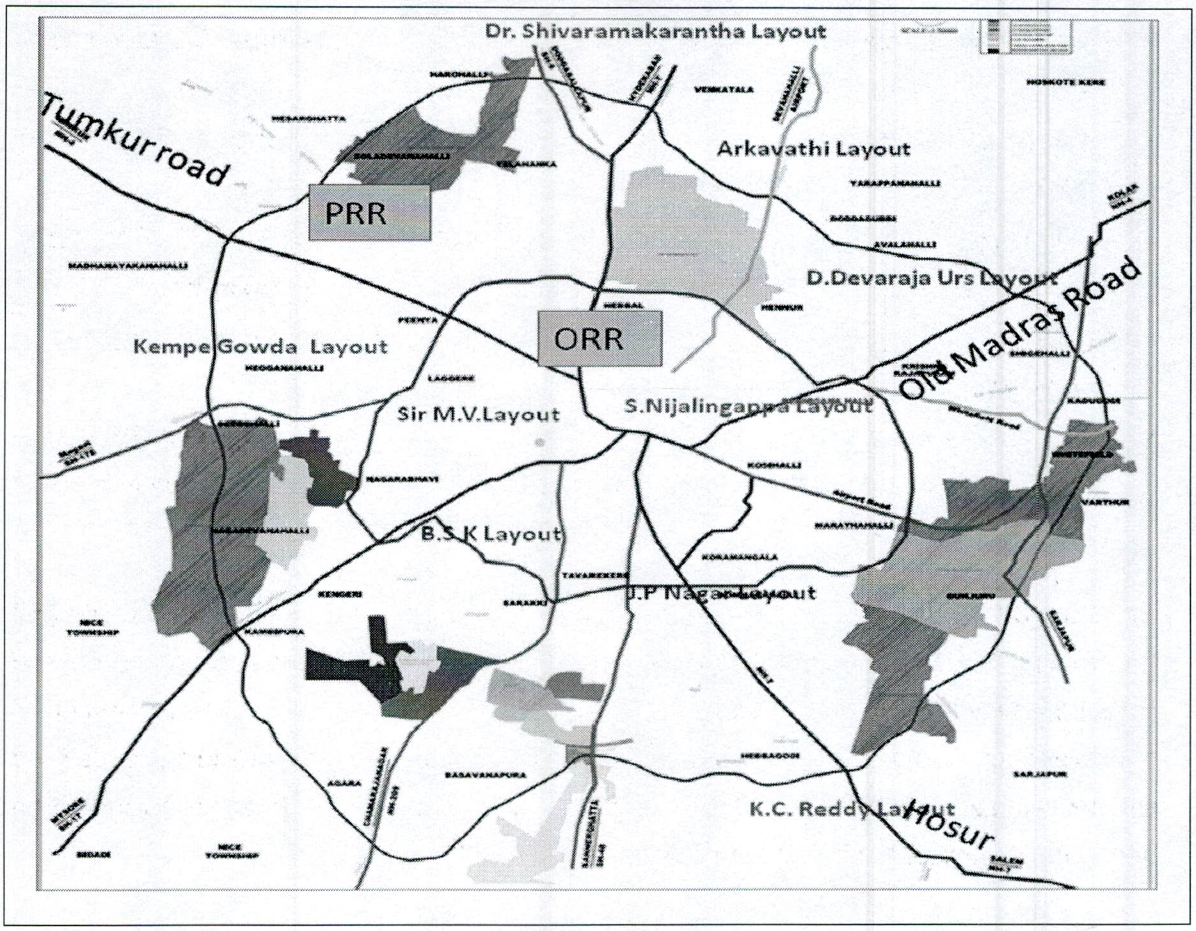
Dr. Shivaramakarantha Layout
Tumkur road
PRR
ORR
Arkavathi Layout
D.Devaraja Urs Layout
Old Madras Road
Kempe Gowda Layout
Sir M.V.Layout
S.Nijalingappa Layout
B.S.K Layout
J.P Nagar Layout
K.C. Reddy Layout
Hosur
HESARGHATTA
YELAHANKA
VENKATALA
HOSKOTE KERE
YARAPPANAHALLI
AVALAHALLI
HENNUR
HEBBAL
PEENYA
HEGGANAHALLI
LAGGERE
NAGARABHAVI
KODIHALLI
Airport Road
MARATHAHALLI
KORAMANGALA
KADUGODI
WHITEFIELD
VARTHUR
TAVAREKERE
KENGERI
NICE TOWNSHIP
BIDADI
AGARA
BASAVANAPURA
HEBBAGODI
SARJAPUR
SALEM NH-7
KOLAR NH-4
NH-7

Figure 2-16: Proposed layouts in and around PRR

2.10.1 Project Road Traffic

Proposed traffic at various sections on PRR are computed as follows:

- (1) - Base Traffic from OD Matrix
- (2) - Reduction in Traffic between Electronic city (south) and Madanayakanahalli (west)
- (3) - Reduction in traffic on account of NH 207 / STRR
- (4) - Generated Traffic on account of development of various layouts

PRR Traffic = 1 - 2 - 3 + 4

The total traffic on PRR is computed section-wise (for three homogenous section and is given in Table 2-21, Table 2-22 and Table 2-23 respectively. It may also be noted that even though toll plazas were proposed at 13 locations on PRR, considering the traffic entry and exit at these locations and proximity to adjoining toll plazas, toll plazas are proposed at only 10 locations. The detailed were presented to Technical Advisory Committee 4th meeting on 05/10/2019 and were approved.

Table 2-21: Total Traffic, Section-1

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Tumkur Road - A	A	Tumkur Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	B	Hesaraghatta Road	184	87	6	33	8	11	14	10	17	0	**370**	**471**
	C	Doddaballapur Road	458	136	40	153	1	61	217	241	165	0	**1472**	**3397**
	D	Bellary Road	4611	3100	106	484	18	424	384	397	282	0	**9806**	**11834**
	E	Hennur Road	1317	410	13	67	1	1	44	35	22	0	**1910**	**2065**
	F	Old Madras Road	155	65	48	139	4	10	184	99	67	0	**771**	**1951**
	G	Whitefield Road	32	27	3	24	3	9	13	11	7	0	**129**	**263**
	H	Chanasandra Road	32	2	0	25	0	4	6	6	5	0	**80**	**162**
	I	B'lore-Sarjapur Road	36	10	16	7	1	1	9	0	4	0	**84**	**126**
	J	Hosur Road	62	36	15	48	10	42	26	24	46	0	**309**	**740**
		Total	**6887**	**3873**	**247**	**980**	**46**	**563**	**897**	**823**	**615**	**0**	**14931**	**21009**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Hessaraghatta Road - B	A	Tumkur Road	6	3	2	23	0	1	6	3	2	0	**46**	**98**
	B	Hesaraghatta Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	C	Doddaballapur Road	1	1	0	0	0	1	0	0	0	0	**3**	**6**
	D	Bellary Road	7	6	3	8	0	0	5	8	15	0	**52**	**145**
	E	Hennur Road	0	0	3	7	0	1	3	5	3	0	**22**	**57**
	F	Old Madras Road	38	22	6	17	2	7	9	9	6	0	**116**	**256**
	G	Whitefield Road	6	6	0	3	2	5	1	0	0	0	**23**	**43**
	H	Chanasandra Road	3	0	0	7	0	0	2	0	0	0	**12**	**24**
	I	B'lore-Sarjapur Road	3	0	0	3	0	0	0	0	0	0	**6**	**9**
	J	Hosur Road	35	31	10	33	4	8	10	6	14	0	**151**	**331**
		Total	**99**	**69**	**24**	**101**	**8**	**23**	**36**	**31**	**40**	**0**	**431**	**969**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Doddaballapur Road - C	A	Tumkur Road	565	391	11	19	0	58	29	40	50	0	**1163**	**1387**
	B	Hesaraghatta Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	C	Doddaballapur Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	D	Bellary Road	41	23	8	25	5	20	38	56	53	0	**269**	**750**
	E	Hennur Road	70	21	7	41	0	9	37	30	32	0	**247**	**569**
	F	Old Madras Road	55	20	2	30	1	6	31	13	17	0	**175**	**378**
	G	Whitefield Road	15	11	4	23	1	2	36	50	21	0	**163**	**479**
	H	Chanasandra Road	150	28	3	19	1	6	29	38	13	0	**287**	**511**
	I	B'lore-Sarjapur Road	7	8	0	0	0	0	7	9	6	0	**37**	**96**
	J	Hosur Road	120	58	18	46	2	14	62	47	35	0	**402**	**862**
		Total	**1023**	**560**	**53**	**203**	**10**	**115**	**269**	**283**	**227**	**0**	**2743**	**5032**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Bellary Road - D	A	Tumkur Road	2327	1442	130	471	6	208	375	344	248	0	**5553**	**8568**
	B	Hesaraghatta Road	46	33	1	24	4	1	32	16	52	0	**209**	**506**
	C	Doddaballapur Road	41	19	7	18	4	13	11	14	9	0	**136**	**314**
	D	Bellary Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	E	Hennur Road	9	10	1	2	0	0	1	1	0	0	**24**	**29**
	F	Old Madras Road	147	100	87	104	2	52	101	53	24	0	**670**	**1473**
	G	Whitefield Road	247	168	9	56	3	11	90	62	35	0	**681**	**1260**
	H	Chanasandra Road	394	117	17	52	1	63	78	74	21	0	**817**	**1482**
	I	B'lore-Sarjapur Road	97	99	2	61	1	26	57	54	25	0	**422**	**922**
	J	Hosur Road	2165	994	51	207	10	268	289	163	139	0	**4286**	**6260**
		Total	**5473**	**2982**	**305**	**995**	**33**	**642**	**1034**	**781**	**553**	**0**	**12798**	**20814**

Table 2-22: Total Traffic, Section-2

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Hennur Road - E	A	Tumkur Road	576	399	7	107	2	32	60	52	60	0	**1295**	**1650**
	B	Hesaraghatta Road	11	12	1	25	2	1	22	22	11	0	**107**	**283**
	C	Doddaballapur Road	81	40	10	41	2	9	28	19	25	0	**255**	**506**
	D	Bellary Road	3	4	4	5	0	1	1	1	0	0	**19**	**36**
	E	Hennur Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	F	Old Madras Road	114	64	27	53	0	62	98	39	28	0	**485**	**1252**
	G	Whitefield Road	29	11	8	7	1	3	3	0	2	0	**64**	**95**
	H	Chanasandra Road	50	6	1	1	0	9	1	0	0	0	**68**	**94**
	I	B'lore-Sarjapur Road	226	71	12	36	0	26	18	55	8	0	**452**	**743**
	J	Hosur Road	899	358	24	47	2	41	82	76	48	0	**1577**	**2026**
		Total	**1989**	**965**	**94**	**322**	**9**	**184**	**313**	**264**	**182**	**0**	**4322**	**6685**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Old Madras Road - F	A	Tumkur Road	343	290	45	90	9	22	189	95	96	0	**1179**	**2343**
	B	Hesaraghatta Road	56	35	10	38	0	2	35	27	30	0	**233**	**526**
	C	Doddaballapur Road	274	144	16	86	1	88	96	47	42	0	**794**	**1624**
	D	Bellary Road	134	65	23	85	10	69	180	97	54	0	**717**	**1895**
	E	Hennur Road	118	64	38	30	1	53	89	31	18	0	**442**	**1051**
	F	Old Madras Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	G	Whitefield Road	74	46	18	39	6	21	91	35	33	0	**363**	**898**
	H	Chanasandra Road	153	56	32	47	2	91	86	62	16	0	**545**	**1337**
	I	B'lore-Sarjapur Road	65	52	9	51	0	69	66	24	34	0	**370**	**946**
	J	Hosur Road	296	200	62	150	9	171	206	144	112	0	**1350**	**3238**
		Total	**1513**	**952**	**253**	**616**	**38**	**586**	**1038**	**562**	**435**	**0**	**5993**	**13858**

Table 2-23: Total Traffic, Section-3

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Whitefield Road - G	A	Tumkur Road	73	57	8	14	4	9	6	12	6	0	**189**	**265**
	B	Hesaraghatta Road	11	8	5	4	0	0	2	0	0	0	**30**	**50**
	C	Doddaballapur Road	60	30	3	9	2	4	11	51	1	0	**171**	**355**
	D	Bellary Road	309	147	12	61	5	11	61	62	7	0	**675**	**1097**
	E	Hennur Road	78	23	4	8	0	0	1	5	0	0	**119**	**136**
	F	Old Madras Road	68	45	12	39	1	5	56	24	8	0	**258**	**534**
	G	Whitefield Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	H	Chanasandra Road	11	6	1	2	1	6	9	3	2	0	**41**	**94**
	I	B'lore-Sarjapur Road	38	42	6	13	0	15	39	56	16	0	**225**	**581**
	J	Hosur Road	99	77	15	33	5	32	110	143	30	0	**544**	**1436**
		Total	**747**	**435**	**66**	**183**	**18**	**82**	**295**	**356**	**70**	**0**	**2252**	**4548**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Chanasandra Road - H	A	Tumkur Road	169	93	3	41	1	10	16	10	29	0	**372**	**536**
	B	Hesaraghatta Road	0	0	1	24	0	0	10	14	4	0	**53**	**153**
	C	Doddaballapur Road	152	33	12	30	0	23	44	63	17	0	**374**	**780**
	D	Bellary Road	260	105	36	51	2	29	78	42	8	0	**611**	**1205**
	E	Hennur Road	33	33	2	5	1	10	3	0	0	0	**87**	**124**
	F	Old Madras Road	155	41	34	85	2	92	67	46	16	0	**538**	**1245**
	G	Whitefield Road	4	0	0	1	0	0	2	2	2	0	**11**	**28**
	H	Chanasandra Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	I	B'lore-Sarjapur Road	68	36	5	14	0	10	25	21	3	0	**182**	**353**
	J	Hosur Road	125	64	13	57	2	31	90	85	29	0	**496**	**1194**
		Total	**966**	**405**	**106**	**308**	**8**	**205**	**335**	**283**	**108**	**0**	**2724**	**5618**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Anekal Road - I	A	Tumkur Road	18	5	1	12	0	0	8	6	0	0	**50**	**100**
	B	Hesaraghatta Road	0	0	0	2	0	0	1	0	0	0	**3**	**8**
	C	Doddaballapur Road	17	5	3	6	0	0	5	9	0	0	**45**	**96**
	D	Bellary Road	94	30	7	36	0	16	59	92	0	0	**334**	**800**
	E	Hennur Road	69	9	8	32	0	8	28	38	22	0	**214**	**496**
	F	Old Madras Road	52	23	12	43	1	25	64	55	25	0	**300**	**805**
	G	Whitefield Road	29	9	3	12	0	38	37	74	21	0	**223**	**695**
	H	Chanasandra Road	35	12	8	28	0	17	12	19	3	0	**134**	**311**
	I	B'lore-Sarjapur Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
	J	Hosur Road	19	9	2	5	0	2	34	37	9	0	**117**	**338**
		Total	**333**	**102**	**44**	**176**	**1**	**106**	**248**	**330**	**80**	**0**	**1420**	**3649**

Vehicle Types			Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehcile	Total Vehicles	Total PCU
Hosur Road - J	A	Tumkur Road	236	166	22	62	7	61	33	27	27	0	**641**	**1033**
	B	Hesaraghatta Road	115	102	6	35	3	24	16	11	26	0	**338**	**544**
	C	Doddaballapur Road	419	146	59	138	5	68	190	216	157	0	**1398**	**3163**
	D	Bellary Road	2763	1039	122	345	15	349	423	423	359	0	**5838**	**10434**
	E	Hennur Road	833	203	34	56	0	17	157	109	64	0	**1473**	**2324**
	F	Old Madras Road	376	214	97	190	12	243	315	285	154	0	**1886**	**5104**
	G	Whitefield Road	178	79	12	41	4	41	60	100	55	0	**570**	**1309**
	H	Chanasandra Road	107	69	20	82	2	30	172	143	56	0	**681**	**1810**
	I	B'lore-Sarjapur Road	7	2	1	3	1	3	43	40	6	0	**106**	**352**
	J	Hosur Road	0	0	0	0	0	0	0	0	0	0	**0**	**0**
		Total	**5034**	**2020**	**373**	**952**	**49**	**836**	**1409**	**1354**	**904**	**0**	**12931**	**26073**

2.11 Traffic Growth Rates

Investment priorities are governed by the traffic demand, estimated benefits and cost of the project. Hence, prediction of traffic demand estimate assumes very significant role in investment priorities. Traffic growth on a road facility is generally estimated on the basis of statistical data and historical trends. In the present case, traffic growth for the project road is estimated using econometric method given in IRC:108-1996.

From the origin destination studies, the project stretch is mainly influenced by adjoining states of Andhra Pradesh (west) and Tamilnadu (on south). Hence, available statistics of both the states and Karnataka is used in estimation of traffic growth rates.

2.11.1 Econometric Method

Given the inconsistencies and absence of accurate past traffic survey data, in this method, the vehicle registration data has been correlated with NSDP. Motor vehicle registration trends of Karnataka have been considered in estimating the traffic demand elasticity. The independent variables are socio-economic parameters. The choice of independent variable depends upon vehicle type under consideration. This method involves a logarithmic regression between two variables and is of the form.

$$\text{Log e } P = Ao + A1^{*} \text{ Log e } NSDP$$

Where,

- P = Vehicle Registration Data
- Ao = Regression Constant
- A1 = Elasticity Coefficient
- NSDP = Net State Domestic Product (economic indicator)

Finally the, after the regression analysis, the elasticity values obtained for each type of vehicle will be multiplied by the average economic growth of the region.

$$Tg = Eg * e$$

Where, Tg is Traffic Growth Rate
Eg is Economic Growth Rate for the Region
"e" is the Traffic Demand elasticity

Traffic growth rates are estimated by multiplying traffic demand elasticity of particular vehicle type with average economic parameter of the region.

2.11.2 Past Vehicle Registration Details

Vehicle registration data of Karnataka, Tamilnadu, Andhra Pradesh – Telangana and Kerala states are collected from various sources and is presented in Table 2-24.

Table 2-24: Vehicle Registration details

Year	Passenger Cars				Bus				LCV			
	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala
2004-05	639548	644917	735851	600566	38052	16909	38415	95486	49530	75845	74380	234191
2005-06	744579	755399	808666	691383	40819	18368	42572	127574	65581	85112	101637	264262
2006-07	816055	634708	890857	717786	45211	45359	43609	396980	130685	131782	103911	247799
2007-08	966397	731718	997340	801187	49586	49480	48325	414678	145809	165918	130659	271763
2008-09	1079318	826968	1107419	905488	44308	53820	53238	430162	161100	194746	148375	291514
2009-10	1160926	910623	1238483	1048877	53874	56664	56997	383229	177179	219332	148249	251471
2010-11	1301702	1025392	1405840	1219949	58012	60622	59926	390430	198378	257147	160002	288447
2011-12	1454309	1217906	1581392	1397990	62501	70075	63503	396826	221160	302124	173857	323891
2012-13	1626924	2027060	1752478	1590625	69718	112032	69009	404153	258701	470290	183433	364323
2013-14	1798035	1368733	1932043	1792711	75529	76650	85472	409961	294266	339819	220765	391401
2014-15	1992262	1514568	2093986	1978598	80911	81691	87757	414748	331381	366768	230717	409745
2015-16	2207852	1752551	2262491	2178202	86544	88657	88965	111835	367572	408232	232309	366326
2016-17	2449146		2450265		93684		86380		400335		236124	
2017-18	2666466		2589123		101445		78896		435888		231625	

Year	Trucks				MAV			
	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala
2004-05	161609	154401	137294		10774	7755	9849	
2005-06	197280	172789	164351		13152	9043	9161	
2006-07	154949	191269	169935	47989	26638	5434	9065	16465
2007-08	167144	211879	206120	49072	31811	6854	6965	16635
2008-09	171905	225543	233057	50057	33592	7872	7812	16811
2009-10	163674	228276	253362	51784	36642	7935	6106	16993
2010-11	176223	233494	270749	55264	40890	8169	6626	17270
2011-12	187939	244475	296667	58969	45483	8940	7385	17361
2012-13	198224	361591	306111	61254	49415	12322	7719	17542
2013-14	206973	253352	320157	67275	54016	9509	7017	17677
2014-15	215027	265144	337779	71734	59944	9922	7266	17837
2015-16	223552	285792	351143	122102	66863	10655	7773	68367
2016-17	232095		346328		74195		14628	
2017-18	239530		340480		81240		17309	

2.11.3 Economic Indicators

Traffic growth on the project road is generally influenced by development prevailing in the influence area. The time series data of economic parameters like National State Domestic Product (NSDP), state population, Per Capita Income (PCI) of influence states and Gross Domestic Product (GDP) at constant (2004-2005) prices published by Central Statistical Organisation are collected to determine the elasticity of influencing states and is given in Table 2-25.

Table 2-25: Few Economic Indicators at (2004-05) Constant Price

Year	Population, in 1000				PCI, Rs				NSDP, Rs Lakh				GDP, Rs Lakh
	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	Karnataka	Andhra Pradesh - Telangana	Tamilnadu	Kerala	
2004-05	55200	78630		32303	26882	25959		32351	14872898	12138779		10477605	297146400
2005-06	56006	79454		32458	29295	27179		35492	16403065	12814975		11549986	325307300
2006-07	56824	80286		32614	31967	29797		38113	18108596	14160969		12462466	356436400
2007-08	57653	81127	68080	32771	35574	33217	41314	41315	20380990	15926959	27233984	13574746	389663600
2008-09	58495	81977	69075	32929	37687	33733	43193	43644	21830924	16334065	28674358	14409392	415867600
2009-10	59349	82836	70084	33087	37294	35677	47394	47360	21836349	17440082	31675986	15712270	451607100
2010-11	60216	83704	71108	33246	40699	37708	53507	50146	24081677	18604072	35996050	16717844	491853300
2011-12	61095	84581	72147	33406	41492	38556	57093	52808	24804028	19155444	38650813	17691461	524753000
2012-13	61987	85467	73201	33567	94382	161596	96890	103551	52864210	62168801	64259300	31727708	854627500
2013-14	62893	86362	74271	33728	101864	168294	101559	107846	57748160	65264118	67512409	33357691	906364900
2014-15	63811	87267	75356	33890	105703	180598	106189	112444	60679872	69914857	71300072	34804833	971213300
2015-16	64743	88181	76457	34053	116819	200876	114581	120387	67404955	77503603	77394599	36395582	1049187000
2016-17	65688	89105	77574	34217	131260	218654	121378	129256	71818535	85420568	80186944	38599834	1131897200
2017-18	66647	90038	78707	34382	142943	239244	129328	136364	79216373	94154818	86501251		1210416500
CAGR,%	1.46%	1.05%	1.46%	0.48%	13.72%	18.63%	12.09%	11.70%	13.73%	17.07%	12.25%	11.48%	11.41%

2.11.4 Elasticity

Regression analysis is carried out between vehicle type and economic parameters with vehicle type as the dependent variable (Y axis) and Economic parameters as independent variable (X axis). Linear regression analysis is carried out on natural logarithm of both parameters. The extent by which both parameters correlate with one another is determined by R2 value tending towards 1.0. Closer the value tending towards 1, better is the correlation.

Linear regression analysis is carried out for GDP, NSDP, PCI and Population with various vehicle classes. The elasticity values corresponding to PCI and Population is considered for Passenger Cars and Buses. NSDP and GDP values are considered for LCV, Trucks and MAV. Details of elasticity values and adopted growth rates are given in Table 2-26.

Table 2-26: Elasticity Values for various indicators

Passenger Cars					
State	Indicators	Elasticity Value	R2	Growth Rate, %	Adopted Growth Rate, %
Karnataka	PCI	0.684	0.898	5.03%	10.93%
	Population	7.483	0.997	10.93%	
Andhra Pradesh - Telangana	PCI	0.423	0.817	2.28%	10.20%
	Population	9.734	0.852	10.20%	
Tamilnadu	PCI	0.700	0.943	4.66%	9.85%
	Population	6.738	0.990	9.85%	
Kerala	PCI	0.772	0.885	4.37%	12.83%
	Population	26.682	0.996	12.83%	

Buses					
State	Indicators	Elasticity Value	R2	Growth Rate, %	Adopted Growth Rate, %
Karnataka	PCI	0.490	0.922	3.60%	7.68%
	Population	5.257	0.982	7.68%	
Andhra Pradesh - Telangana	PCI	0.501	0.533	2.69%	14.16%
	Population	13.513	0.765	14.16%	
Tamilnadu	PCI	0.465	0.895	3.10%	6.21%
	Population	4.251	0.847	6.21%	
Kerala	PCI	0.383	0.198	2.17%	6.97%
	Population	14.485	0.266	6.97%	

LCV					
State	Indicators	Elasticity Value	R2	Growth Rate, %	Adopted Growth Rate, %
Karnataka	NSDP	0.938	0.809	8.43%	9.29%
	GDP	1.183	0.853	9.29%	
Andhra Pradesh - Telangana	NSDP	0.675	0.702	4.24%	9.53%
	GDP	1.198	0.828	9.53%	
Tamilnadu	NSDP	0.470	0.935	3.27%	3.27%
	GDP	0.486	0.935	3.59%	
Kerala	NSDP	0.413	0.876	3.14%	2.40%
	GDP	0.395	0.876	2.40%	

Trucks					
State	Indicators	Elasticity Value	R2	Growth Rate, %	Adopted Growth Rate, %
Karnataka	NSDP	0.206	0.794	1.85%	1.85%
	GDP	0.252	0.787	1.98%	
Andhra Pradesh - Telangana	NSDP	0.249	0.663	1.57%	3.43%
	GDP	0.431	0.741	3.43%	
Tamilnadu	NSDP	0.370	0.885	2.57%	2.57%
	GDP	0.378	0.869	2.80%	
Kerala	NSDP	0.515	0.649	3.13%	3.13%
	GDP	0.555	0.690	4.22%	

MAV					
State	Indicators	Elasticity Value	R2	Growth Rate, %	Adopted Growth Rate, %
Karnataka	NSDP	1.064	0.809	8.36%	7.55%
	GDP	0.840	0.761	7.55%	
Andhra Pradesh - Telangana	NSDP	0.214	0.553	1.34%	2.75%
	GDP	0.346	0.544	2.75%	
Tamilnadu	NSDP	0.444	0.364	3.09%	3.09%
	GDP	0.483	0.404	3.57%	
Kerala	NSDP	0.501	0.249	3.05%	3.05%
	GDP	0.556	0.281	4.23%	

Based on Origin Destination survey, influence factors of various classes are determined. The final growth rates are worked out in proportion of the influence factors of the region. Section-wise break up of traffic growth rates is given in Table 2-27.

Table 2-27: Influence Factors and Traffic Growths for various sections

	Section - 1										
		Influence Factors						Traffic Growth Rate			
	Car	LCV	Bus	Trucks	MAV		Car	LCV	Bus	Trucks	MAV
Karnataka	94.02%	89.40%	97.04%	76.72%	69.42%		10.93%	8.43%	7.68%	1.85%	7.55%
Kerala	0.10%	0.30%	0.04%	0.76%	0.99%		12.83%	2.40%	6.97%	3.13%	3.05%
Tamilnadu	1.43%	2.54%	0.64%	6.18%	10.45%		9.85%	3.27%	6.21%	2.57%	3.09%
Andhra Pradesh & Telangana	4.13%	5.86%	1.69%	10.18%	9.83%		10.20%	4.24%	14.16%	3.43%	2.75%
Rest of India	0.32%	1.91%	0.59%	6.16%	9.31%						
Growth Rate	10.88%	8.03%	7.78%	2.08%	6.47%						
	Section - 2										
		Influence Factors						Traffic Growth Rate			
	Car	LCV	Bus	Trucks	MAV		Car	LCV	Bus	Trucks	MAV
Karnataka	87.49%	82.73%	90.65%	79.80%	75.19%		10.93%	8.43%	7.68%	1.85%	7.55%
Kerala	0.12%	0.07%	0.23%	0.03%	0.06%		12.83%	2.40%	6.97%	3.13%	3.05%
Tamilnadu	0.94%	1.51%	0.43%	1.94%	1.24%		9.85%	3.27%	6.21%	2.57%	3.09%
Andhra Pradesh & Telangana	11.37%	15.42%	8.63%	17.73%	22.98%		10.20%	4.24%	14.16%	3.43%	2.75%
Rest of India	0.09%	0.26%	0.06%	0.50%	0.53%						
Growth Rate	10.84%	7.70%	8.23%	2.15%	6.39%						
	Section - 3										
		Influence Factors						Traffic Growth Rate			
	Car	LCV	Bus	Trucks	MAV		Car	LCV	Bus	Trucks	MAV
Karnataka	77.19%	77.12%	82.62%	73.48%	69.66%		10.93%	8.43%	7.68%	1.85%	7.55%
Kerala	0.66%	0.28%	0.73%	0.20%	0.38%		12.83%	2.40%	6.97%	3.13%	3.05%
Tamilnadu	18.93%	18.53%	15.03%	19.48%	18.74%		9.85%	3.27%	6.21%	2.57%	3.09%
Andhra Pradesh & Telangana	3.09%	3.40%	1.59%	5.75%	9.77%		10.20%	4.24%	14.16%	3.43%	2.75%
Rest of India	0.12%	0.68%	0.02%	1.09%	1.45%						
Growth Rate	10.71%	7.31%	7.55%	2.09%	6.21%						

2.11.5 Review of available past traffic data

The consultant had carried out traffic census at 4 National Highway road very close to proposed PRR alignment in 2007. Traffic revalidation survey is also carried out in 2012 to update the traffic numbers. Fresh traffic surveys were carried out in Jan 2019. Comparison is made between traffic numbers between 2007, 2012 and 2019 and average growth rates are worked out. These are given in Table 2-28.

Table 2-28: Comparison of Traffic between 2007 and 2019

Tumkur road						Bellary Road				
Vehicles	2007	2012	2019	CAGR,%		Vehicles	2007	2012	2019	CAGR,%
Car	11457	17834	43891	21.2%		Car	10789	42527	85939	34.5%
Mini Bus	645	789	549	-2.3%		Mini Bus	475	643	161	-14.3%
Bus	3203	3931	4921	6.3%		Bus	1375	2307	2759	10.5%
LCV	4316	6818	9310	11.6%		LCV	1967	2979	3456	8.4%
2AT	3839	5139	3311	-2.1%		2AT	896	943	1721	9.8%
3AT	3367	4909	2723	-3.0%		3AT	644	786	1256	10.0%
MAV	614	1754	5272	36.0%		MAV	207	308	851	22.4%
Total Trucks	7820	11802	11306	5.4%		Total Trucks	1747	2037	3828	11.9%

Old Madras Road						Hosur Road				
Vehicles	2007	2012	2019	CAGR,%		Vehicles	2007	2012	2019	CAGR,%
Car	8347	13740	24330	16.5%		Car	8136	13672	26642	18.5%
Mini Bus	590	737	147	-18.0%		Mini Bus	565	695	150	-17.3%
Bus	2564	3268	3905	6.2%		Bus	2376	3011	3583	6.0%
LCV	2972	4618	6551	12.0%		LCV	3523	5257	4502	3.6%
2AT	2293	2958	3603	6.7%		2AT	2439	3286	6678	15.5%
3AT	1082	1547	1719	6.8%		3AT	3257	4795	5033	6.4%
MAV	329	514	1115	19.0%		MAV	744	1160	4103	27.6%
Total Trucks	3704	5019	6437	8.2%		Total Trucks	6440	9241	15814	13.7%

2.11.6 Comparison of Growth rates

Registered traffic data based on Regional Transport Office (R.T.O) of Bangalore city (urban and rural) are collected (ref Table 2-29). The average growth rate for various classes of vehicles are computed. Details are given in Table 2-30. The registered vehicular growth for various category of vehicles varies in rural and urban areas significantly except in the case of Taxis. Car growth is 10.1% in urban whereas 5% in Bangalore rural. Growth of LMV is 5.5% in Bangalore Urban whereas is is 2.1% in rural section. Bus and Trucks growth is 8.1% and 6.6% in Bangalore urban as against 12.4% and 4.4% in Bangalore Rural. Hence, it is difficult to estimate the traffic growth of PRR project based on vehicle registration data alone.

Table 2-29: Vehicle Registration Details

Vehicle Registration Details Category wise (**BENGALURU URBAN** as on March 31st)								
Sl. No.	Category of vehicles	2012	2013	2014	2015	2016	2017	2018
Non-Transport Vehicles								
1	Two Wheelers	2867646	3158133	3479208	3841139	4222676	4731159	5134055
2	Cars	800866	894865	988101	1088587	1191541	1321815	1432374
3	Jeeps	7313	7343	7413	7443	7485	7672	7784
4	Omni buses	46888	47373	47802	48138	48392	49117	49709
5	Tractors	7875	8450	9040	9432	9830	14638	15662
6	Trailers	6151	6635	7082	7398	7694	11150	11677
7	Construction equipment vehicles	1371	1634	1820	1914	2021	2200	2343
8	other vehicles	19083	19703	21547	21943	25717	27407	30617
Total Non-Transport vehicles		**3757193**	**4144136**	**4562013**	**5025994**	**5515356**	**6165158**	**6684221**
Transport Vehicles								
9	Multi-axled/articulated vehicle	28333	30466	32893	35782	39041	43062	47566
10	Trucks & Lorry	48510	51526	54180	56632	59086	62495	65151
11	**Light Goods Vehicles**							
a	4 Wheelers	40954	49179	56297	63492	70970	79455	87852
b	3 Wheelers	32934	35117	37241	39305	42352	73822	46303
12	**Buses**							
a	Stage carriages	12611	13423	14248	14432	14485	14458	16121
b	Contract carriages	658	842	1020	1255	1622	2044	2236
c	Private service vehcles	6576	7274	8029	9092	10347	10978	11350
d	Educational institution buses	4776	5551	6494	7729	8704	9841	10953
e	Other buses	4539	4884	5052	5188	5412	5745	5927
13	**Taxi**							
a	Motor cabs	24113	30763	36333	45425	64594	91757	105062
b	Maxi cabs	21122	23953	26079	28641	32715	35562	37762
c	Other taxi	1000	2174	3852	6138	10867	140655	14426
14	**Light Motor Vehicles**							
a	3 seaters(A/R)	110377	126590	138470	149944	162932	173584	185344
b	4-6 seaters	23966	24421	25863	27745	30123	32592	33589
15	other vehicles	38470	40877	41993	42936	44271	49191	52339
Total Transport Vehicles		**398939**	**447040**	**488044**	**533736**	**597521**	**825241**	**721981**
Grand total		**4156132**	**4591176**	**5050057**	**5559730**	**6112877**	**6990399**	**7406202**

Vehicle Registration Details Category wise (**BENGALURU RURAL** as on March 31st)						
Sl. No.	Category of vehicles	2012	2013	2014	2015	2016
Non-Transport Vehicles						
1	Two Wheelers	98074	105664	114176	123371	132343
2	Cars	16138	17130	17908	18752	19626
3	Jeeps	135	166	184	184	184
4	Omni buses	500	500	500	500	501
5	Tractors	4070	4241	4468	4784	4960
6	Trailers	3263	3376	3504	3678	3768
7	Construction equipment vehicles	0	180	182	182	182
8	other vehicles	105	159	328	353	688
Total Non-Transport vehicles		**122285**	**131416**	**141250**	**151804**	**162252**
Transport Vehicles						
9	Multi-axled/articulated vehicle	274	361	418	453	478
10	Trucks & Lorry	2476	2581	2655	2729	2784
11	**Light Goods Vehicles**					
a	4 Wheelers	2034	2394	2733	3001	3247
b	3 Wheelers	293	320	368	394	414
12	**Buses**					
a	Stage carriages	32	33	36	37	37
b	Contract carriages	68	77	85	86	88
c	Private service vehcles	178	187	199	222	240
d	Educational institution buses	128	155	192	227	270
e	Other buses	0	4	6	7	13
13	**Taxi**					
a	Motor cabs	70	96	119	158	212
b	Maxi cabs	199	232	268	285	301
c	Other taxi	34	94	106	118	128
14	**Light Motor Vehicles**					
a	3 seaters(A/R)	686	858	961	1148	1348
b	4-6 seaters	165	186	205	221	303
15	other vehicles	2395	2423	2433	2433	2484
Total Transport Vehicles		**9032**	**10001**	**10784**	**11519**	**12347**
Grand total		**131317**	**141417**	**152034**	**163323**	**174599**

Table 2-30: Summary of Vehicular Growth Rates

Vehicle Registration Details, Bangalore Urban								
Vehicles	2012	2013	2014	2015	2016	2017	2018	CAGR,%
T/w	2867646	3158133	3479208	3841139	4222676	4731159	5134055	10.2%
Autos	110377	126590	138470	149944	162932	173584	185344	9.0%
Cars	808179	902208	995514	1096030	1199026	1329487	1440158	10.1%
Taxi	46235	56890	66264	80204	108176	267974	157250	22.6%
LMV	62436	65298	67856	70681	74394	81783	85928	5.5%
Buses	29160	31974	34843	37696	40570	43066	46587	8.1%
Trucks	76843	81992	87073	92414	98127	105557	112717	6.6%
Other Vehicles	155256	168091	180829	191622	206976	257789	244163	7.8%

Vehicle Registration Details, Bangalore Rural						
Vehicles	2012	2013	2014	2015	2016	CAGR,%
T/w	98074	105664	114176	123371	132343	7.8%
Autos	686	858	961	1148	1348	18.4%
Cars	16273	17296	18092	18936	19810	5.0%
Taxi	303	422	493	561	641	20.6%
LMV	2560	2609	2638	2654	2787	2.1%
Buses	406	456	518	579	648	12.4%
Trucks	2750	2942	3073	3182	3262	4.4%
Other Vehicles	10265	11170	12083	12892	13760	7.6%

2.11.7 Comparison of Growth rates

The traffic growth rates derived by econometric method is compared with growth rates from past traffic data and is presented in section-wise. The final growth rates adopted for the project are rationalized and worked out in an increment of 5 years. Details are given in Table 2-31.

Table 2-31: Adopted Traffic Growth Rates - Diverted Traffic

			Section-1				
	Car	LCV	Mini Bus	Bus	2 axle truck	3 axle truck	Multi axle vehicles
2019-2023	10.88%	8.03%	5.00%	7.78%	2.08%	6.47%	6.47%
2024-2028	9.79%	7.23%	5.00%	7.00%	2.08%	5.82%	5.82%
2029-2033	8.81%	6.50%	5.00%	6.30%	2.08%	5.24%	5.24%
2033-2038	7.93%	5.85%	5.00%	5.67%	2.08%	5.00%	5.00%
2038-2043	7.14%	5.27%	5.00%	5.10%	2.08%	5.00%	5.00%
2044-2048	6.42%	5.00%	5.00%	5.00%	2.08%	5.00%	5.00%
2049-2053	5.78%	5.00%	5.00%	5.00%	2.08%	5.00%	5.00%

			Section-2				
	Car	LCV	Mini Bus	Bus	2 axle truck	3 axle truck	Multi axle vehicles
2019-2023	10.84%	7.70%	5.00%	8.23%	2.15%	6.39%	6.39%
2024-2028	9.76%	6.93%	5.00%	7.41%	2.15%	5.75%	5.75%
2029-2033	8.78%	6.24%	5.00%	6.67%	2.15%	5.18%	5.18%
2033-2038	7.90%	5.61%	5.00%	6.00%	2.15%	5.00%	5.00%
2038-2043	7.11%	5.05%	5.00%	5.40%	2.15%	5.00%	5.00%
2044-2048	6.40%	5.00%	5.00%	5.00%	2.15%	5.00%	5.00%
2049-2053	5.76%	5.00%	5.00%	5.00%	2.15%	5.00%	5.00%

			Section-3				
	Car	LCV	Mini Bus	Bus	2 axle truck	3 axle truck	Multi axle vehicles
2019-2023	10.71%	7.31%	5.00%	7.55%	2.09%	6.21%	6.21%
2024-2028	9.64%	6.58%	5.00%	6.80%	2.09%	5.59%	5.59%
2029-2033	8.68%	5.92%	5.00%	6.12%	2.09%	5.03%	5.03%
2033-2038	7.81%	5.33%	5.00%	5.50%	2.09%	5.00%	5.00%
2038-2043	7.03%	5.00%	5.00%	5.00%	2.09%	5.00%	5.00%
2044-2048	6.32%	5.00%	5.00%	5.00%	2.09%	5.00%	5.00%
2049-2053	5.69%	5.00%	5.00%	5.00%	2.09%	5.00%	5.00%

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2.11.8 Traffic Growth – Generated Traffic

Generated traffic generally comprises of T/w, auto, passenger cars and buses due to the development of layouts and its requirement for connectivity to adjoining areas and Bangalore city. Personalised vehicular growth may show an increasing trend at initial stage and then start declining. The proposal for other transportation facilities like metro / mono rail will also be a major consideration in traffic growth in and around PRR after some period when PRR is implemented.

The traffic likely to be generated on account of layouts are slow moving and car traffic. Of the traffic generated from the layout, small proportion of passenger cars and commercial vehicles will use main road of PRR. In a report submitted to BDA, it is found that based on the study carried out by Central Road Research Institute (CRRI) has reported that annual traffic growth vary in the range of 2%–4% in central zone, 5%–7% in the intermediate zone and 8%-9% in Bangalore. The project road falls in intermediate zone with traffic growth varying between 5% and 7%, which is constituted by Two wheelers, autos, cars and small proportion of commercial vehicles. Since, only passenger car movement is expected on main road of PRR from these layouts, traffic growths will be much lesser than the one applicable for intermediate zone. This has been considered in traffic growth estimates. Considering this, following growth factors are adopted as given in Table 2-32.

Table 2-32: Traffic Growth, Generated Traffic

Generated	Car	LCV	Mini Bus	Bus	2AT	3AT	MAV
2019-2023	4.50%	4.00%	3.00%	4.00%	2.00%	2.00%	2.00%
2024-2028	4.95%	4.20%	3.15%	4.20%	2.00%	2.00%	2.00%
2029-2033	4.70%	3.78%	2.84%	3.78%	2.00%	2.00%	2.00%
2033-2038	4.23%	3.40%	2.55%	3.40%	2.00%	2.00%	2.00%
2039-2043	3.81%	3.06%	2.30%	3.06%	2.00%	2.00%	2.00%
2044-2048	3.43%	2.76%	2.07%	2.76%	2.00%	2.00%	2.00%
2049-2053	3.09%	2.48%	1.86%	2.48%	2.00%	2.00%	2.00%

2.12 Capacity Analysis

Capacity of road project road sections are estimated in accordance with Indian Highway Capacity Manual (Indo-HCM), December 2017. Lane capacity for main road of PRR is worked out based on the guidelines given in Chapter 4: Interurban and Urban Expressways. Lane capacities for each of the sections are worked out as follows:

- Stream Equivalency Factor (SEF, S_e) is worked out using equations 4C.6, Section 4C.2 of Annexure 4C.
- Equivalent PCU is computed by multiplying total number of vehicles with SEF for each sub-sections.
- From Traffic volume count survey carried out at various road sections, Peak Hour Factor (PHF) and Direction Distribution Factor (DDF) is estimated. It is assumed that the PHF and DDF on the existing road will prevail on PRR also.
- Peak Hour Traffic is computed by multiplying Daily Traffic (PCU) with PHF and DDF. Peak hour traffic is computed separately for diverted and generated traffic separately. The summary of Peak Hour Traffic adopted for capacity analysis is given in Table 2-33.

Table 2-33: Summary of Peak Hour Traffic

Annual Average Daily Traffic														
From	To	Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehicle	Total, No	Total, PCU	PHT, PCU
TKR	HSR	11137	6439	608	1155	382	887	1437	1166	1075	0	24286	38890	2856
HSR	DBP	11312	6574	692	1266	405	930	1563	1273	1218	0	25233	41500	3138
DBP	BLY	11845	6578	902	1429	491	1076	1939	1657	1433	0	27350	48110	2973
BLY	HNR	11494	4736	1056	1345	571	1317	2510	1947	1448	0	26424	52245	3232
HNR	OMR	11902	4659	1059	1334	671	1491	2791	2137	1485	0	27529	56187	3728
OMR	WHT	11647	4516	1234	1137	644	1836	2732	2302	1500	0	27548	58188	3555
WHT	CHN	10929	4223	1089	1073	610	1880	2617	2364	1505	0	26290	56959	3538
CHN	SRJ	9679	3903	972	974	515	1623	2486	2271	1462	0	23885	52326	3342
SRJ	HOS	9390	3674	970	934	516	1581	2479	2342	1432	0	23318	51786	3309

Peak Hour Traffic														
From	To	Small Car	Big Car	LCV - Passenger	LCV - Goods	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	4 to 6 Axle Trucks	7 or more Axle Vehicle	Total, No	Total, PCU	PHT, PCU
TKR	HSR	817	472	45	85	28	65	105	86	79	0	1782	2853	195
HSR	DBP	855	497	52	95	30	70	118	96	92	0	1905	3133	219
DBP	BLY	732	407	55	88	30	66	120	102	88	0	1688	2969	169
BLY	HNR	711	293	66	84	35	81	155	120	90	0	1635	3233	182
HNR	OMR	790	309	70	89	44	98	186	142	99	0	1827	3729	225
OMR	WHT	712	276	76	69	40	113	167	141	91	0	1685	3559	200
WHT	CHN	679	262	68	66	38	117	162	147	93	0	1632	3537	205
CHN	SRJ	618	249	62	62	33	103	159	145	93	0	1524	3339	199
SRJ	HOS	600	235	62	60	33	101	158	150	91	0	1490	3309	198

Capacity of three homogenous sections are worked out considering capacity per lane as 2300 PCU / Hour in accordance with Table 4.2, Section 4.5.2 of Indo-HCM Manual. This value corresponds to 8 lane divided urban road. Bangalore Metro Rail Corporation Limited (BMRCL) is implementing metro connecting various parts of the city. As part of phasing plan, existing Outer Ring Road (from Central Silk Board to Hebbal), Electronic city on south, Whitefield on West and Bengaluru International Airport on north will be connected. This will reduce traffic on road with shift in ridership from personalized transport to Mass transport facility. Hence, in the capacity analysis, reduction in vehicles on account of Metro is considered 2024 onwards.

Summary of projected traffic volume and no of travel lanes required for 3 homogenous sections are computed and given in Table 2-34.

Table 2-34: Capacity Analysis

Year	Section-1 (Tumkur Road to Bellary Road)		Section-2 (Bellary Road to Old Madras Road)		Section-3 (Old Madras Road to Hosur Road)	
	Peak PCU / Hr	No of Lanes	Peak PCU / Hr	No of Lanes	Peak PCU / Hr	No of Lanes
2019	3713	2	4238	2	2595	2
2020	4017	2	4550	2	2819	2
2021	4343	2	4882	3	3066	2
2022	4700	3	5244	3	3332	2
2023	5085	3	5628	3	3622	2
2024	4439	2	5386	3	3169	2
2025	4762	3	5739	3	3410	2
2026	5106	3	6112	3	3672	2
2027	5473	3	6521	3	3956	2
2028	5866	3	6950	4	4261	2
2029	6251	3	7370	4	4562	2
2030	6661	3	7818	4	4885	3
2031	7097	4	8294	4	5231	3
2032	7565	4	8797	4	5606	3
2033	8067	4	9334	5	6005	3

Year	Section-1 (Tumkur Road to Bellary Road)		Section-2 (Bellary Road to Old Madras Road)		Section-3 (Old Madras Road to Hosur Road)	
	Peak PCU / Hr	No of Lanes	Peak PCU / Hr	No of Lanes	Peak PCU / Hr	No of Lanes
2034	8560	4	9863	5	6401	3
2035	9085	4	10431	5	6822	3
2036	9639	5	11023	5	7272	4
2037	10230	5	11650	6	7753	4
2038	10853	5	12311	6	8269	4
2039	11469	5	12967	6	8776	4
2040	12131	6	13664	6	9314	5
2041	12820	6	14399	7	9883	5
2042	13558	6	15166	7	10491	5
2043	14344	7	15983	7	11135	5
2044	15128	7	16801	8	11765	6
2045	15953	7	17653	8	12435	6
2046	16820	8	18559	9	13139	6
2047	17730	8	19507	9	13886	7
2048	18696	9	20502	9	14676	7
2049	19656	9	21509	10	15450	7
2050	20659	9	22568	10	16263	8
2051	21710	10	23677	11	17118	8
2052	22824	10	24845	11	18022	8

The main road sections (1,2, and 3) of PRR will reach its capacity in year 2045, 2043 and 2049 respectively. This is based on the assumptions and considerations made in traffic growth estimate as on date. As discussed during 4th meeting of TAC, the traffic growth for the project shall be computed at regular time period after project implementation and traffic projections, lane requirements and V/c ratio to be assessed.

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SECTION – 3

DESIGN STANDARDS

3 DESIGN STANDARDS

3.1 Introduction

Peripheral Ring Road is an access controlled facility for main road traffic movement intended to provide efficient, speedy movement of relatively high volumes of heavy motorized traffic with higher degree of safety, comfort and economy. Alignment characteristics and cross section elements and facilities should be such that the facility at all point of time is amenable for widening / improvement with provisions to accommodate other transportation systems as and when required depending on the traffic growth and projections.

The proposed PRR will be located at a radial distance of 17–25 Km from city centre. Hence, the roadway facilities proposed and design parameters finalized should take into account fast moving traffic like trucks, multi axle vehicles and long distance passenger cars on main road and at the same time slow moving vehicles like T/w, auto and non motorised traffic and bus services on service roads. Hence, the choice of design parameters depends on the traffic mix proposed across the cross section (main road and service road).

3.2 Design Philosophy

The design philosophy adopted for development of project road is from the guidelines prescribed in various standards of Indian Road Congress. While it is important to provide higher standards of design at initial stage, it is equally important that such proposals are rendered cost effective. Hence, the planning parameters of design are developed under following standards:

- The desirable standards which could be adopted as a rule
- The minimum standards, which could be accepted for difficult stretches where application of the desirable standards, would lead to exorbitant costs due to excessive land acquisitions.

Even though the main road of PRR is proposed to be access controlled facility for fast moving commercial and passenger car traffic, the design provisions are not taken from IRC:SP:99-2013 “Manual of Specifications and Standards for Expressways” or from IRC Design Manual applicable for National Highways as many roadway parameters like Right of Way, C/w dimensions, Design Speed and the mix of traffic are different. The design speed for the project is governed by the land already earmarked for the project road by Bangalore Development Authority and various other requirements like space for future transportation system, space for ITS equipment, service road, utility corridor etc. are to be retro-fit within the available ROW. In this regard the consultant had detailed discussions with BDA, DULT and TAC and finally adopted IRC: 86-2018 "Geometric Design Standards for Urban Roads and Streets" as the primary codal reference for the alignment.

3.3 Project Features

Peripheral Ring road is proposed to access controlled facility for main road traffic which comprises of passenger cars, trucks, light commercial vehicles and buses. Since the project road passes through urban / semi urban area around Bangalore city, considerable local traffic is also expected in addition to generated traffic. Local traffic, which essentially comprises of T/w, autos, BMTC bus services, tractors, bicycles use service roads which are proposed on either side of main road. Due the development on both sides of road, crossing facilities for local users will also be required – both for passenger vehicles and for pedestrians. Hence, it is necessary to provide access / entry / exit points at suitable locations where traffic movement is expected. For the project, entry and exit points are provided at major radial road networks in the form of Underpasses / Grade Separators.

3.4 Road Design

3.4.1 Terrain Classification

The general slope of the country classifies the terrain across the area. The terrain is an important parameter governing the geometric standards and the criteria given in Table 3-1 are used in classifying terrain under these categories. While classifying a terrain, short isolated stretches of varying terrain are not taken into consideration. The proposed road is generally in plan terrain for most length.

Table 3-1: Terrain Classification Recommended by IRC

Terrain Classification	Cross slope of the country	
Plain	0 – 10	More than 1 in 10
Rolling	10 –25	1 in 10 to 1 in 4
Mountainous	25 –60	1 in 4 to 1 in 1.67
Steep	>60	Less than 1 in 1.67

3.4.2 Design Speed

Design speed is the basic criterion for determining all geometric features of horizontal and vertical alignments. The design speeds for various terrain conditions given in Clause 3.2 of

IRC:86 for various road classification and terrain condition. The details are given in Table 3-2. Design speed is mainly be used to determine the following parameters:

- Horizontal curve and super elevation parameters
- Length of Vertical Curves / K factors
- Geometric layout of the interchanges (specifically layout of the accesses, including length of taper and merging areas, and weaving zones)
- Layout and characteristics of signs

Table 3-2: Design Speeds to be adopted for Different Terrain

Class of Urban Road	Type of Terrain		
	Plain	**Rolling**	**Mountainous & Steep**
Urban Expressway	80	70	60
Arterial Road	60	50	40
Sub Arterial Road	60	50	40
Collector Street	40	40	30
Local Street	30	30	30

The project corridor is finalized by BDA considering availability of land free of major encumbrances. Since horizontal geometry has to be fit within the project corridor already acquired by BDA, design speed of 60 Kmph is considered for main road design. It is emphasized here that the horizontal alignment for the PRR project is based on the right of way marked by BDA and the horizontal alignment (which is exactly center of 100m ROW) is designed with geometry which caters for speed of more than 60 Kmph. Service road is proposed for 30 Kmph considering local traffic which includes slow moving traffic and non motorised traffic.

3.5 Typical Cross Section

The project corridor width is approved by the Government vide No. 214 dated 03/10/2019. Accordingly, the project road will be with 100m Right of Way comprising of main road, service road, road side drains, footpath etc., Typical cross section for the project consists of the following cross section elements:

- Alignment will be concentric w.r.t ROW with horizontal geometric design.

- Main Road, 14m wide with 0.5m edge strip and space for gantry of 0.75m on central median side, 1.5m paved shoulder and 0.75m space for gantry on separator median (service road) side
- Service Road, 10.5m wide, with 0.25m kerb shy distance each next to main road separated by separator drain.
- 2m cycle track, 2m wide footpath, 1m exclusive space for U/G cables and 2m wide space for other utilities beyond service road towards ROW.
- 1m wide drain next to service road
- 5m green space at end of ROW on both sides.
- Central median of 13m.

Typical cross sections are developed for the project road considering the following:

- Sections with normal embankment with flat ground across the section
- Section at locations of underpass approaches
- Sections at locations of flyover approaches
- Sections at locations of ROB / RUB approaches
- Sections requiring earth retaining structures between main road and service roads

Typical cross sections adopted for the project is given from Figure 3-1 to Figure 3-15.

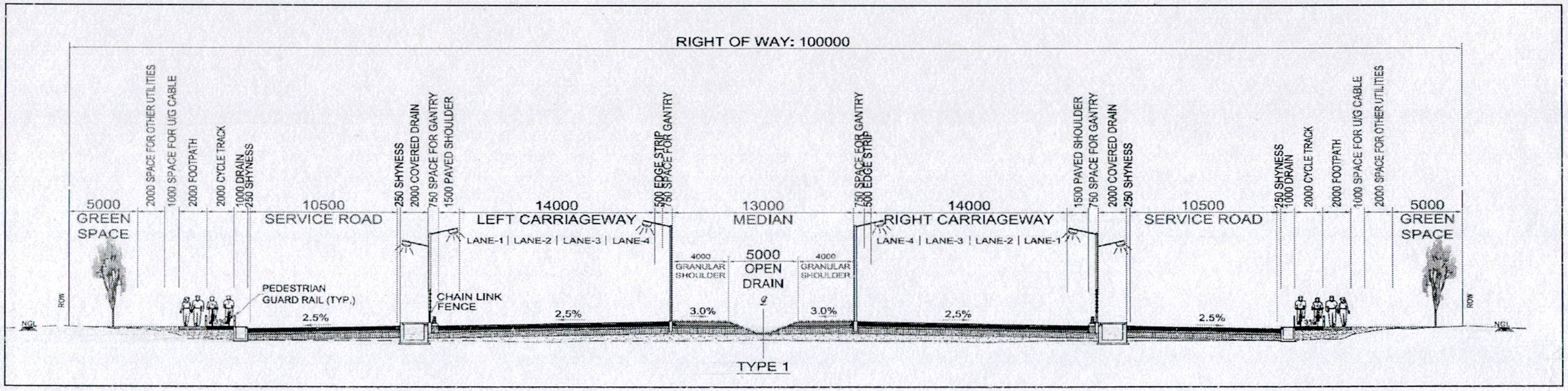

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
750 SPACE FOR GANTRY
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
750 SPACE FOR GANTRY
13000
MEDIAN
4000
GRANULAR SHOULDER
5000
OPEN DRAIN
750 SPACE FOR GANTRY
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
750 SPACE FOR GANTRY
2000 COVERED DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
PEDESTRIAN GUARD RAIL (TYP.)
CHAIN LINK FENCE
2.5%
3.0%
ROW
NGL
TYPE 1

Figure 3-1: Typical Cross Section - at grade

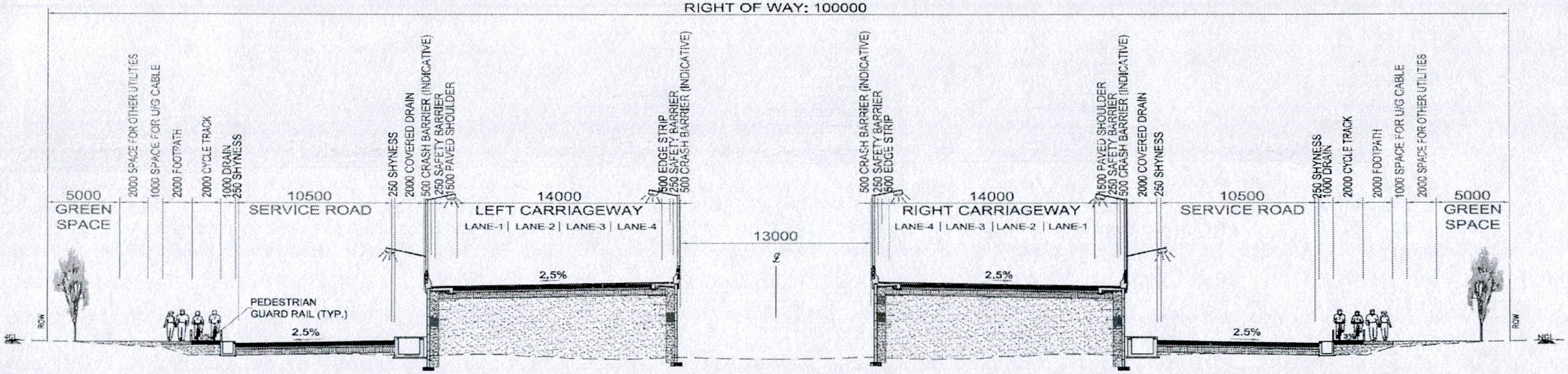

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
13000
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
2000 COVERED DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
ROW
NGL

Figure 3-2: Typical Cross Section at VUP and PUP approaches

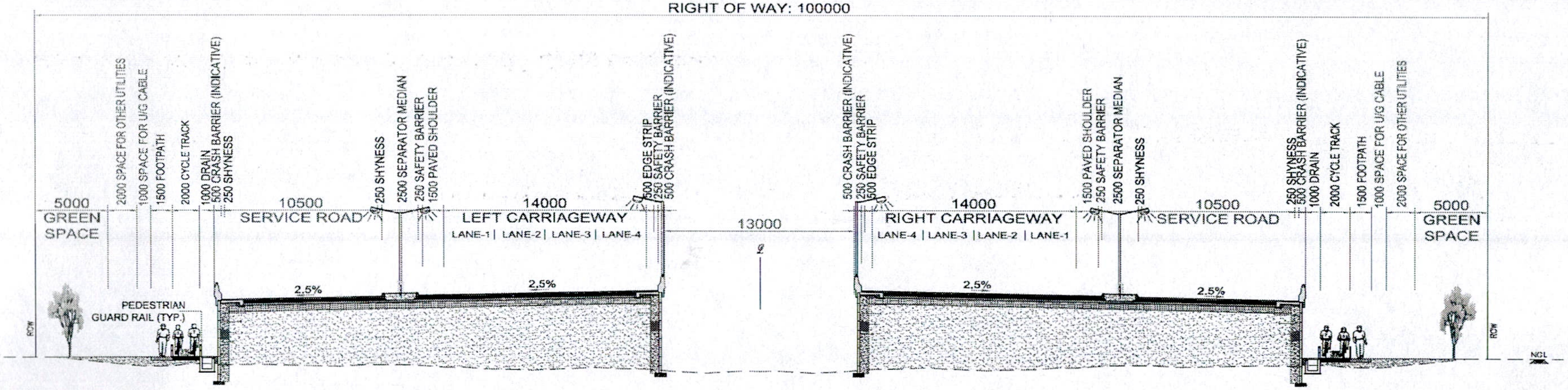

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
1500 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2500 SEPARATOR MEDIAN
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
13000
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
2500 SEPARATOR MEDIAN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
500 CRASH BARRIER (INDICATIVE)
1000 DRAIN
2000 CYCLE TRACK
1500 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
2,5%
2,5%
2,5%
2,5%
PEDESTRIAN
GUARD RAIL (TYP.)
ROW
ROW
NGL

Figure 3-3: Typical Cross Section at ROB approaches

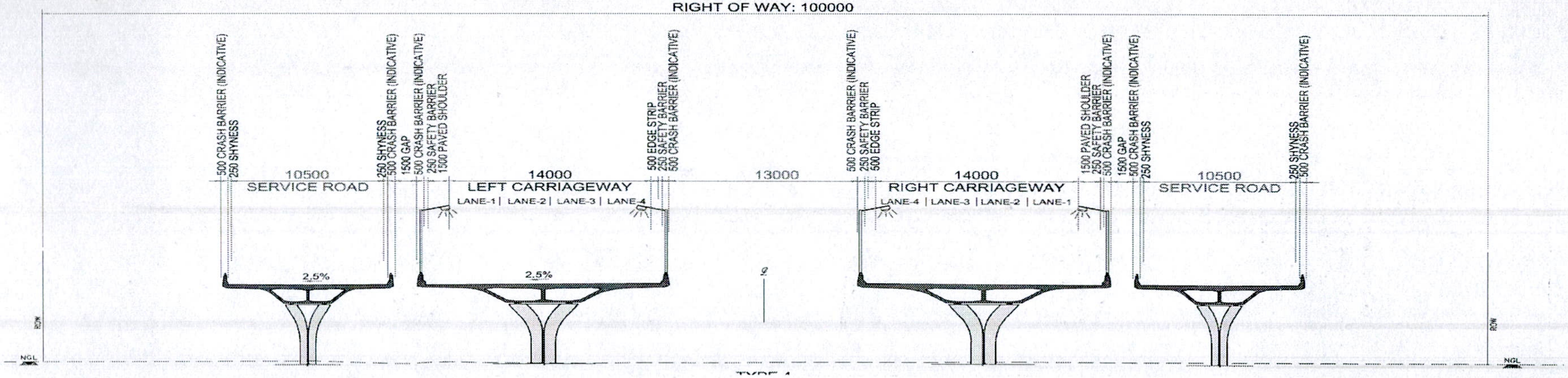

RIGHT OF WAY: 100000
500 CRASH BARRIER (INDICATIVE)
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
500 CRASH BARRIER (INDICATIVE)
1500 GAP
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
13000
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
1500 GAP
500 CRASH BARRIER (INDICATIVE)
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
500 CRASH BARRIER (INDICATIVE)
2,5%
2,5%
ROW
ROW
NGL
NGL

Figure 3-4: Typical Cross Section at ROB crossing portion

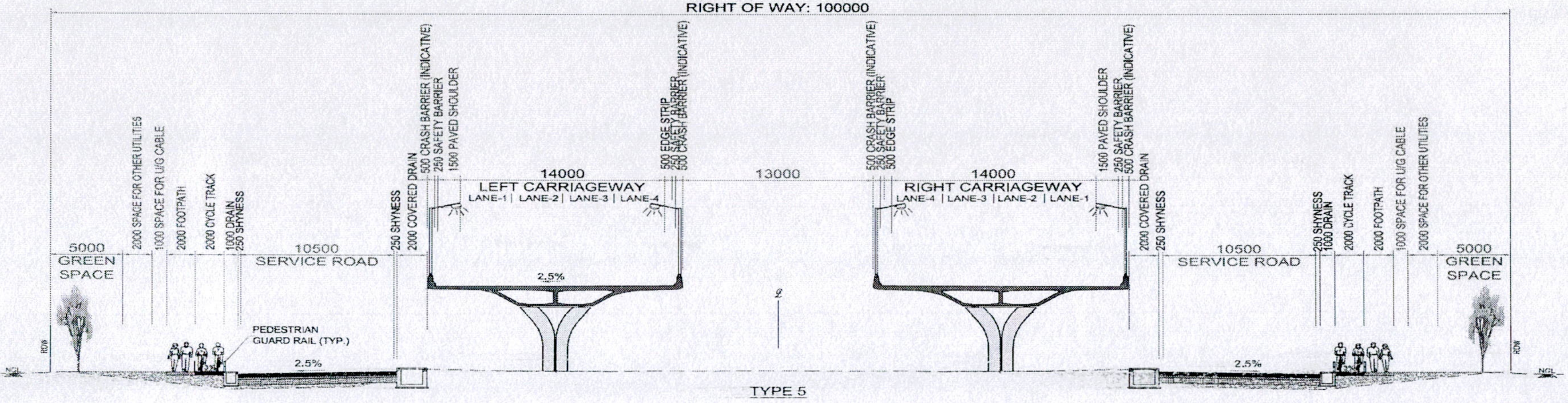

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
13000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
2.5%
PEDESTRIAN GUARD RAIL (TYP.)
ROW
NGL
TYPE 5

Figure 3-5: Typical Cross Section at flyover portion

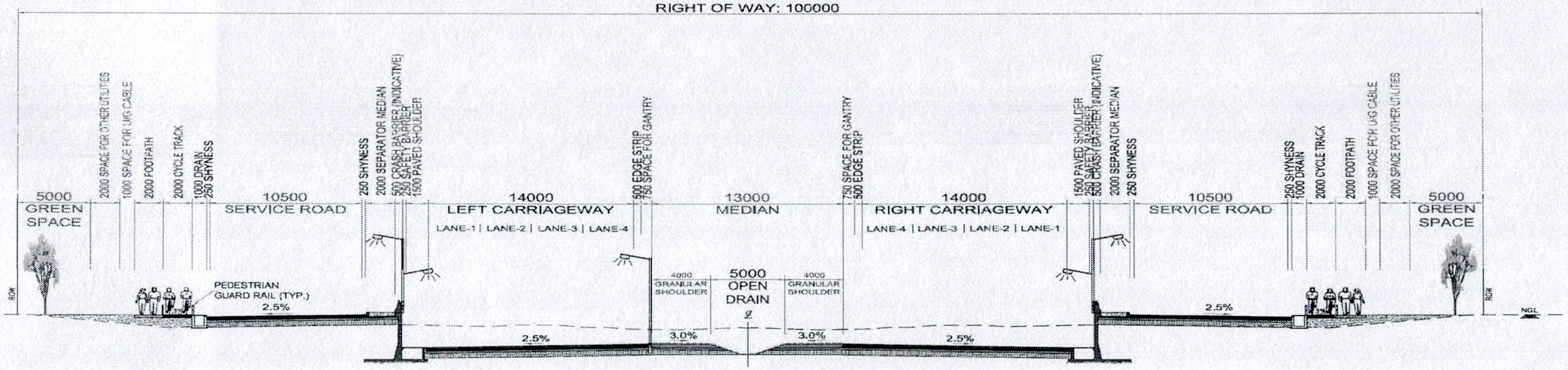

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 SEPARATOR MEDIAN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
750 SPACE FOR GANTRY
13000
MEDIAN
4000 GRANULAR SHOULDER
5000 OPEN DRAIN
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
2.5%
3.0%
PEDESTRIAN GUARD RAIL (TYP.)
ROW
NGL

Figure 3-6: Typical Cross Section - PRR Main road is below major road crossings

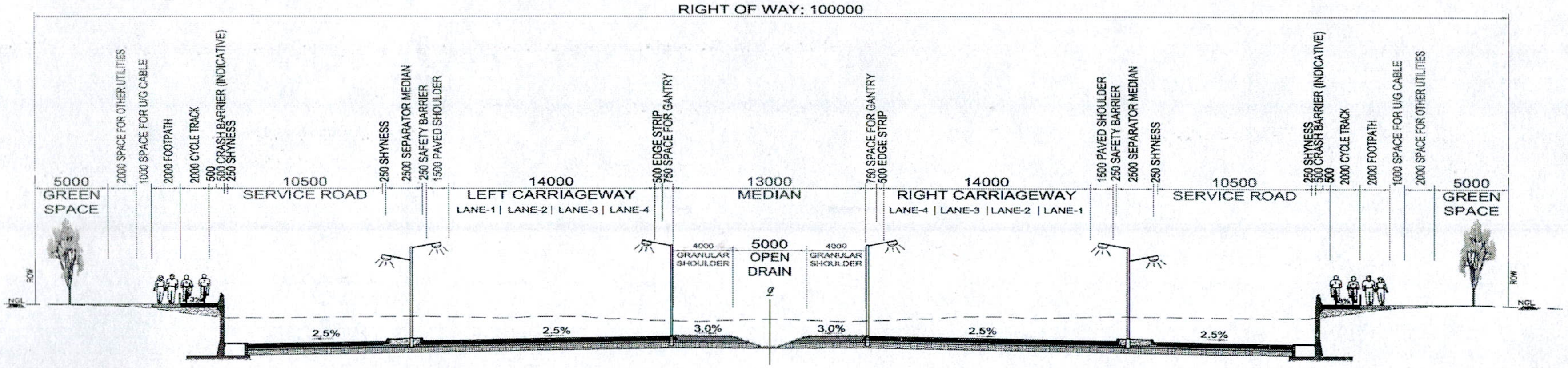

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
500
500 CRASH BARRIER (INDICATIVE)
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2500 SEPARATOR MEDIAN
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
750 SPACE FOR GANTRY
13000
MEDIAN
4000
GRANULAR SHOULDER
5000
OPEN DRAIN
4000
GRANULAR SHOULDER
750 SPACE FOR GANTRY
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
2500 SEPARATOR MEDIAN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
500 CRASH BARRIER (INDICATIVE)
500
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
ROW
NGL
2.5%
2.5%
3.0%
3.0%
2.5%
2.5%

Figure 3-7: Typical Cross Section at RUB Approach Location

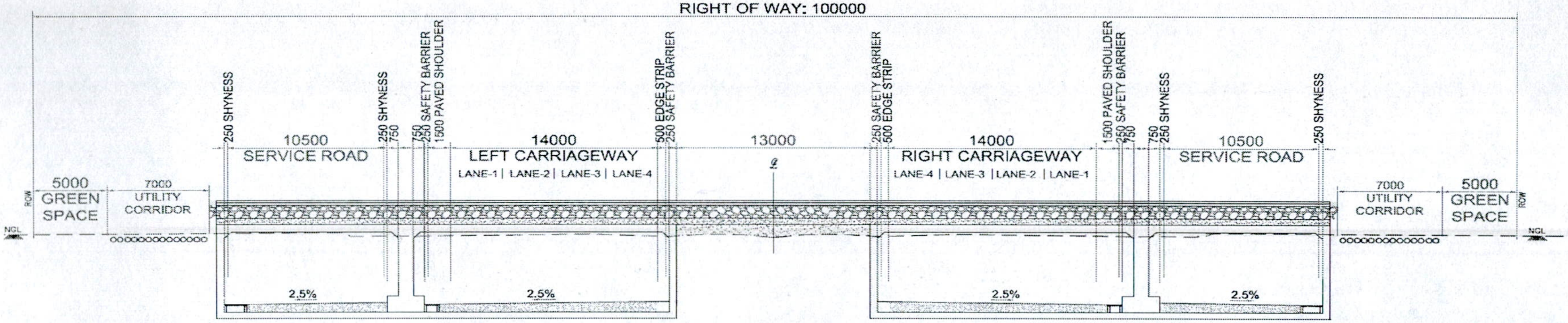

RIGHT OF WAY: 100000
5000
GREEN SPACE
7000
UTILITY CORRIDOR
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
750
750
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
13000
250 SAFETY BARRIER
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
750
750
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
7000
UTILITY CORRIDOR
5000
GREEN SPACE
ROW
NGL
2.5%
2.5%
2.5%
2.5%

Figure 3-8: Typical Cross Section at RUB

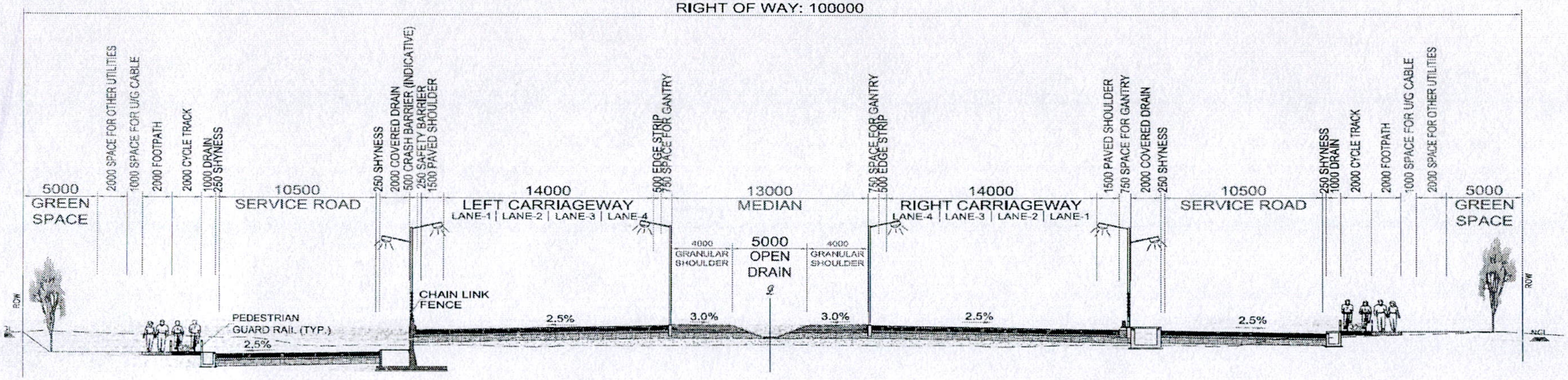

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
750 SPACE FOR GANTRY
13000
MEDIAN
4000
GRANULAR SHOULDER
5000
OPEN DRAIN
4000
GRANULAR SHOULDER
750 SPACE FOR GANTRY
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
750 SPACE FOR GANTRY
2000 COVERED DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
CHAIN LINK FENCE
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
2.5%
3.0%
3.0%
2.5%
2.5%
ROW
ROW
NGL

Figure 3-9: Typical Cross Section – LSR lower than Main road

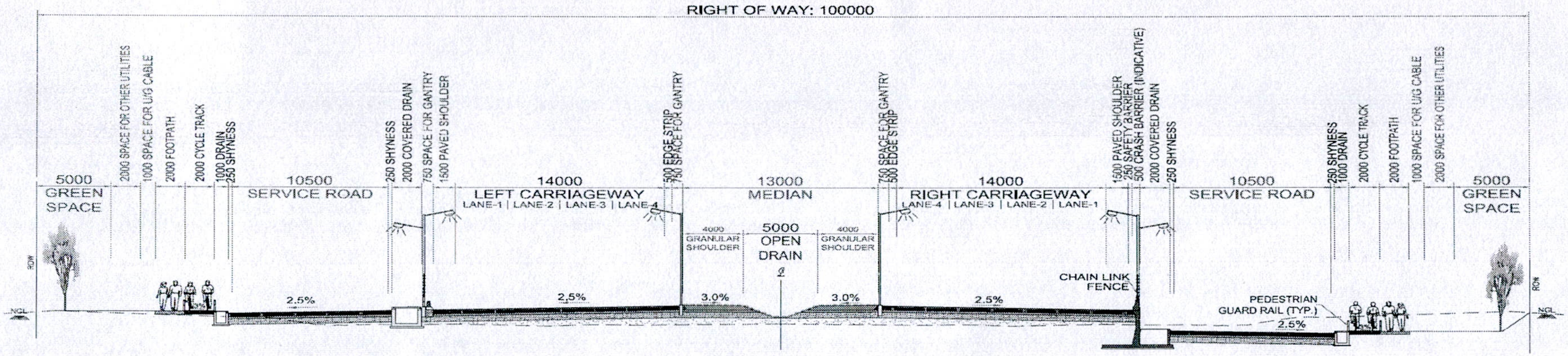

RIGHT OF WAY: 100000
5000
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
750 SPACE FOR GANTRY
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
750 SPACE FOR GANTRY
13000
MEDIAN
4000
GRANULAR SHOULDER
5000
OPEN DRAIN
4000
GRANULAR SHOULDER
750 SPACE FOR GANTRY
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
2000 COVERED DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
CHAIN LINK FENCE
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
2.5%
3.0%
3.0%
2.5%
2.5%
ROW
ROW
NGL
NGL

Figure 3-10: Typical Cross Section – RSR lower than Main road

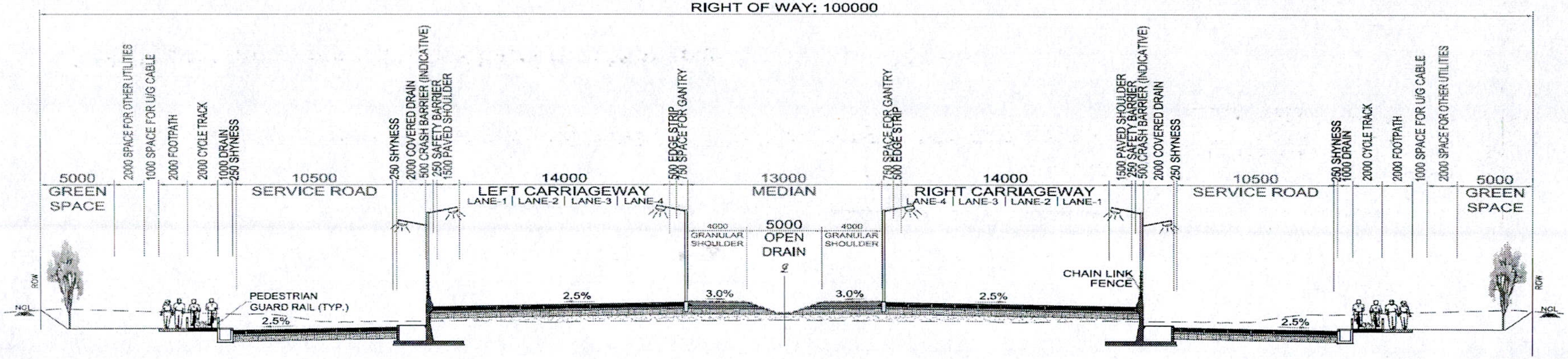

RIGHT OF WAY: 100000
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
500 EDGE STRIP
750 SPACE FOR GANTRY
750 SPACE FOR GANTRY
500 EDGE STRIP
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
2000 COVERED DRAIN
250 SHYNESS
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
10500
SERVICE ROAD
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
13000
MEDIAN
4000 GRANULAR SHOULDER
5000 OPEN DRAIN
4000 GRANULAR SHOULDER
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
10500
SERVICE ROAD
5000
GREEN SPACE
CHAIN LINK FENCE
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
2.5%
3.0%
3.0%
2.5%
2.5%
ROW
NGL
ROW
NGL

Figure 3-11: Typical Cross Section – Service Road lower than Main road

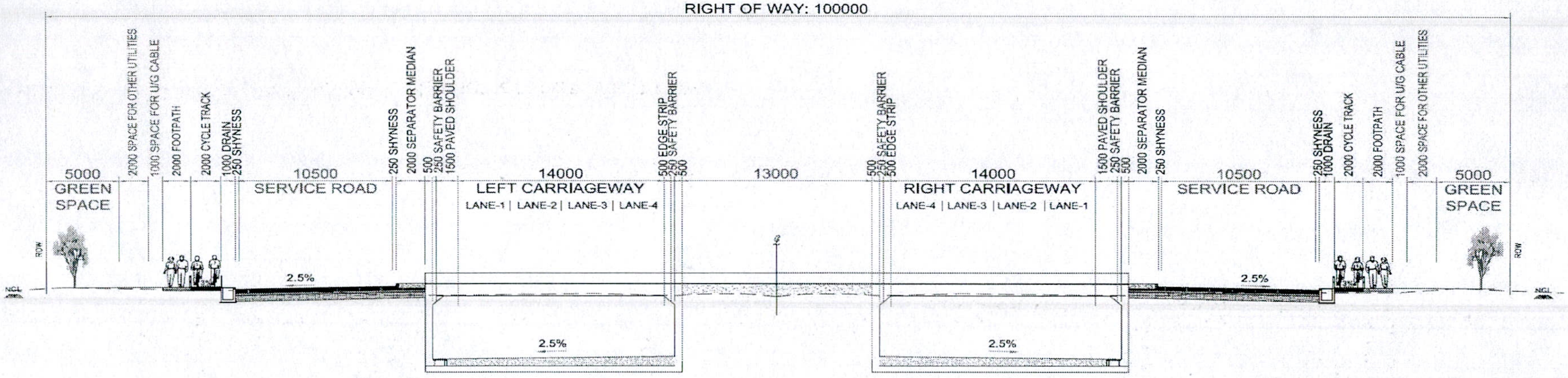

RIGHT OF WAY: 100000
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
250 SHYNESS
2000 SEPARATOR MEDIAN
500
250 SAFETY BARRIER
1500 PAVED SHOULDER
500 EDGE STRIP
500 SAFETY BARRIER
500
500 SAFETY BARRIER
500 EDGE STRIP
1500 PAVED SHOULDER
250 SAFETY BARRIER
500
2000 SEPARATOR MEDIAN
250 SHYNESS
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
5000
GREEN SPACE
10500
SERVICE ROAD
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
13000
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
10500
SERVICE ROAD
5000
GREEN SPACE
2.5%
2.5%
2.5%
2.5%
ROW
NGL
ROW
NGL

Figure 3-12: Typical Cross Section – At Underpass Location

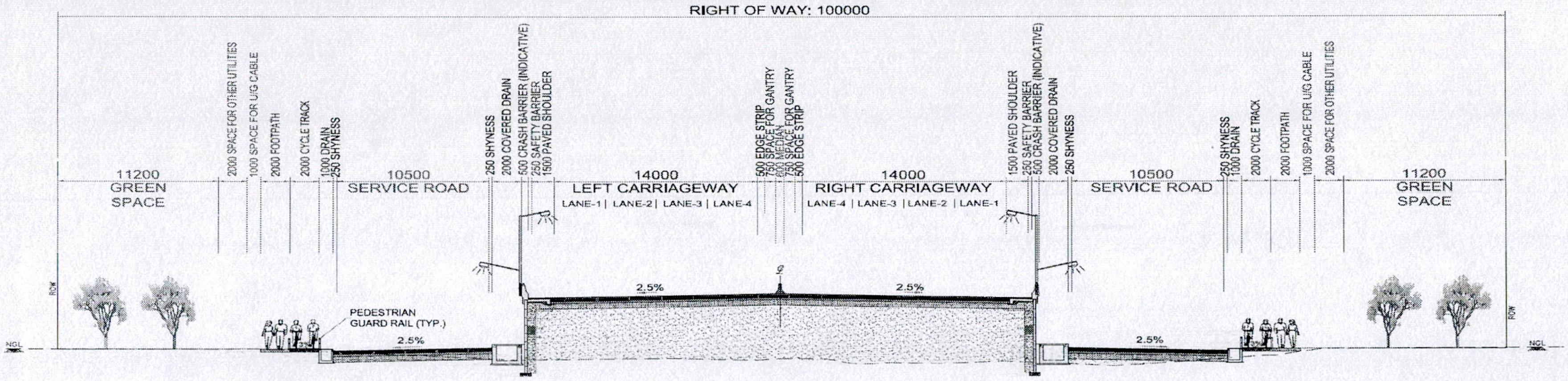

RIGHT OF WAY: 100000
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
500 EDGE STRIP
750 SPACE FOR GANTRY
600 MEDIAN
750 SPACE FOR GANTRY
500 EDGE STRIP
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
2000 COVERED DRAIN
250 SHYNESS
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
11200
GREEN SPACE
10500
SERVICE ROAD
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
10500
SERVICE ROAD
11200
GREEN SPACE
2.5%
2.5%
2.5%
2.5%
PEDESTRIAN GUARD RAIL (TYP.)
ROW
ROW
NGL
NGL

Figure 3-13: Typical Cross Section – At Hosur Road Flyover Approach Location

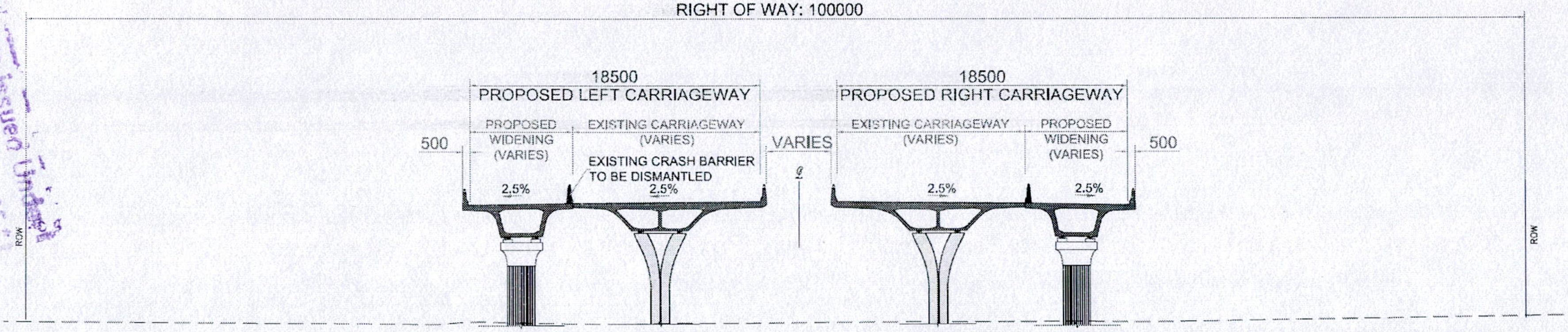

RIGHT OF WAY: 100000
18500
PROPOSED LEFT CARRIAGEWAY
PROPOSED WIDENING (VARIES)
EXISTING CARRIAGEWAY (VARIES)
EXISTING CRASH BARRIER TO BE DISMANTLED
18500
PROPOSED RIGHT CARRIAGEWAY
EXISTING CARRIAGEWAY (VARIES)
PROPOSED WIDENING (VARIES)
500
VARIES
500
2.5%
2.5%
2.5%
2.5%
ROW
ROW

Figure 3-14: Typical Cross Section – At Tumkur Road & Hosur Road Flyover Portion

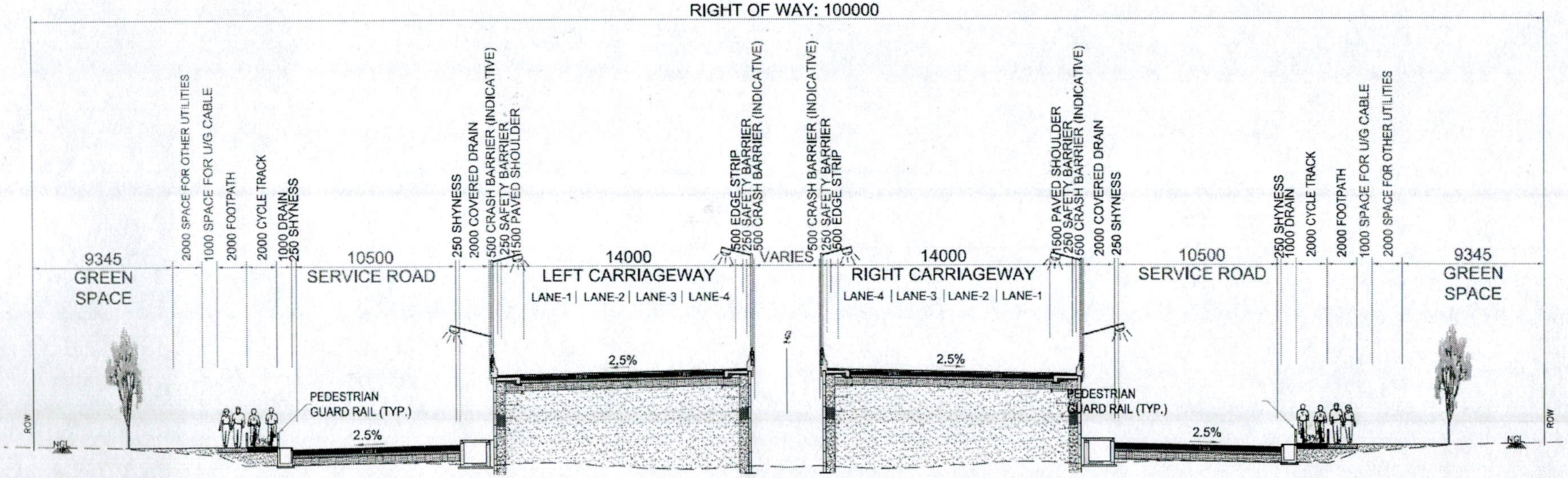

RIGHT OF WAY: 100000
9345
GREEN SPACE
2000 SPACE FOR OTHER UTILITIES
1000 SPACE FOR U/G CABLE
2000 FOOTPATH
2000 CYCLE TRACK
1000 DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
2000 COVERED DRAIN
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
1500 PAVED SHOULDER
14000
LEFT CARRIAGEWAY
LANE-1 | LANE-2 | LANE-3 | LANE-4
500 EDGE STRIP
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
VARIES
500 CRASH BARRIER (INDICATIVE)
250 SAFETY BARRIER
500 EDGE STRIP
14000
RIGHT CARRIAGEWAY
LANE-4 | LANE-3 | LANE-2 | LANE-1
1500 PAVED SHOULDER
250 SAFETY BARRIER
500 CRASH BARRIER (INDICATIVE)
2000 COVERED DRAIN
250 SHYNESS
10500
SERVICE ROAD
250 SHYNESS
1000 DRAIN
2000 CYCLE TRACK
2000 FOOTPATH
1000 SPACE FOR U/G CABLE
2000 SPACE FOR OTHER UTILITIES
9345
GREEN SPACE
2.5%
2.5%
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
PEDESTRIAN GUARD RAIL (TYP.)
2.5%
ROW
NGL
NGL
ROW

Figure 3-15: Typical Cross Section – At Tumkur Road Flyover Approach Location

3.5.1 Cross Sectional Elements

The cross section elements for the project is governed by roadway proposed to be acquired by BDA, type of facility proposed to be given for fast moving traffic and slow moving traffic, buffer space for other mass transportation facilities in future, space for pedestrian walkway and utilities. Cross Section elements proposed for the project is given in following sections.

3.5.2 Road Land width

Road land width also termed as right-of-way is the width of land acquired for road construction. The total land acquisition for PRR is 100m, except at locations of toll plaza and interchanges where more land width is required.

3.5.3 Lane width

The lane width of single lane is considered as 3.5m as per clause 5.4 of IRC:86. Hence, the total width of four lane configuration will be 14m, each traffic direction. This excludes shy distance.

Width of service road is proposed as 10.5m as per Table 5, clause 6.2.4 of IRC: 86-1983.

3.5.4 Width of the Shoulder

Paved shoulder of 1.5m in width next to main c/w as per IRC: 86-1983 guidelines.

3.5.5 Median width

The width of central median is proposed to be 13m separating traffic directions. The width of 13m is adopted considering space requirements for other mass transportation facilities like Metro / Mono / BRTS in future.

3.5.6 Camber

Camber of 2.5% is proposed for main road and service road. Camber of main road and service road is oriented towards drain. This is as per Clause 6.1 of IRC:86.

3.5.7 Side Slopes

As the ROW is restricted, there is very little chance of providing natural slope. As a result of this retaining wall is provided where ever required.

3.6 Horizontal Alignment

3.6.1 Horizontal Curve

Horizontal curve consists of circular portion flanked by spiral transition at both ends. Design speed, super elevation and coefficient of side friction govern the design of circular curves. The provision of transition curves enhances the safety of the road users, as it will allow a smooth change in the rate of change of superelevation, and also reduces the centrifugal forces on the vehicle. Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation, whichever is higher. Design of horizontal curves is based on Clause 8.1 of IRC:86 and IRC :38. Minimum radius of curve corresponding to design speed of 60 Kmph and limiting superelevation to 4% will be 150m as per Clause 8.2.1 of IRC:86.

Minimum length of horizontal curve is derived from the equation:

$$R = \frac{V^2}{127(e+f)}$$

Where

R is the minimum radius of curve, m

V is the Design Speed, Kmph

'e' is Superelevation

f' is the coefficient of side friction between vehicle tyres and pavement (taken as 0.15)

Minimum length of horizontal curve required to be provided is 150m.

3.6.2 Transition Curve

Transition curves are computed as per guidelines given in Clause 8.5 of IRC:86. Transition curve has a radius which decreases from infinity at the tangent point to a designated radius of the circular curve. Transition curves on highways are provided to bring about gradual change in carriageway rotation from normal camber of 2.5% to the value equal to that of super elevation. This will be required to counteract centrifugal force a vehicle will develop during negotiating a horizontal curve. Transition curve adopted in the design is taken as highest of the following values (clause 7.3, IRC: 38-1988)

- Rate of change of centrifugal acceleration

$$L_s = \frac{0.0215V^2}{CR}$$ and C = $$\frac{80}{75+V}$$

Where

Ls is length of transition curve, m

V is the Design Speed, Kmph

R is the Radius of Curve, m

- Rate of change of super elevation (1 in 150), Ls = C/w x e x 150

Where

Ls is length of transition curve, m

e is the super elevation provided

C/w is carriageway width, m

- Empherical formula as per IRC

$$L_s = \frac{2.7V^2}{R} \quad \text{or} \quad L_s = \frac{1.0\,V^2}{R}$$

Considering above conditions, the minimum length of transition curve required will be 130m for Minimum Design Speed and limit the superelevation to 4%.

3.6.3 Superelevation

Superelevation is generally considered to counteract only a fixed percentage of the centrifugal force developed on horizontal curves, so that the slow moving traffic will be aided through the curve. For the project, maximum super elevation adopted is 4% as per clause 8.2.1 of IRC:86-1983. Superelevation is calculated by the following formula.

$$e = \frac{V^2}{225R}$$

Where

'e' is Superelevation

'V' is the design speed in Km/h

'R' is the radius in meters

Radius more than or equal to 640 m will not require rotation of carriageway for counteracting centrifugal force.

Since paved shoulder is provided as part of main road and slow moving traffic are not allowed, extra widening on curves are not provided. Also, the minimum curve radius provided in the design is 400m, whereas extra widening is required if the curve radius is less than or equal to 300m as per Clause 8.6 of IRC:86.

3.7 Vertical Alignment

The guideline given in Clause 9.1 of IRC:86 in conjunction with IRC: SP: 23-1983 will be followed for the design of vertical alignment.

3.7.1 Gradients

The gradients adopted in the design are as per guidelines given in clause 9 of IRC:86. The allowable difference in grade where no vertical curve is required is 0.8 for design speed of 60 Kmph. The minimum length of vertical curve required for summit and valley curve will be 40m. The maximum gradient adopted in vertical design is restricted to 4.0%.

3.7.2 Combination of Horizontal and Vertical Curves

Where the vertical and horizontal curves cannot be separated, sufficient care has been taken to contain the vertical curves within, and where it was not possible, they were kept outside the horizontal curve. Horizontal alignment and vertical profile are made as flat as possible at intersections, where sight distance is an important design aspect.

3.8 Drainage

Following drainage facilities are made in the design:

- Open drain in central median
- Separator drains between main road and service road, with cross fall towards drain.
- Drain under next to service road under footpath.

Drainage provisions will be in accordance with IRC: SP: 50 guidelines for the project. The sizings of the drain, including the inverts are dependent on hydraulic and hydrological particulars.

3.9 Other Cross Section Elements

Following are the other provisions made in the cross section for the project. The provisions listed below are discussed with BDA and TAC on various occasions and finalised.

3.9.1 Cycle Track

Cycle track with width of 2m is proposed next to service road on ROW side. Cycle track will be provided with paver block pavement.

3.9.2 Footpath

Footpath will be provided next to cycle track. Width of footpath will be 2m. In order to differentiate cycle track from footpath, 50mm offset will be proposed between them. In addition, the colour of the paving blocks of footpath and cycle track will be different.

3.9.3 Utility Space

Space for utilities next to footpath will be proposed. The utility space will consist of 1m corridor for U/G cable and 2m for other utilities.

3.9.4 Green Space

5m wide green strip will be provided at end of Right of Way.

3.10 Facilities Proposed

Following are the facilities proposed as part of the project.

- Grade Separators, Flyovers at Major intersections
- Vehicular Underpasses at other road crossings
- Toll Plazas at entry / exit points (grade separators & Flyover locations)
- Space provision for Bus Stop / Bus Shelter on service road
- Illumination

3.11 Traffic Safety Appurtenances

Following are the road safety / appurtenances proposed for the project:

- Traffic Road Signs
- Pavement Marking
- Raised Pavement Markers
- Object Marking
- Crash Barrier – Metal Beam / New Jersey
- Pedestrian Guard Rail
- Embankment protection works like stone pitching / turfing

3.12 General Design Basis – Structures

The project road comprises of various structures like box `culverts, minor bridges, flyovers, underpasses and railway crossing structures. The design considerations shall be in accordance with applicable IRC codes of practices. General guidelines governing the designs are given in following sections. At some of the structure locations, PRR project road is above the ground and at some locations below the ground. At some other locations, PRR will be at grade level and the cross road will be above or below the existing road. The structures shall be designed for minimum 100 years design life.

3.12.1 Super-Structure type

Superstructure type for proposed bridge, underpass, ROB and flyovers will be with RCC Box type structures, RCC Solid Slab, RCC Voided Slab, RCC T-beam girders, PSC Girders and PSC box girders, Steel composite girders and Boq String girders. The type if superstructure depends on the span and type of structure.

3.12.2 Sub-Structure

Sub structure comprises of solid RCC piers which will be positioned such a way that the natural stream of flow is not blocked and therefore will not effect velocity of flow. Circular/Square/Rectangular/wall shaped piers shall be reviewed for adopting after considering the aesthetics and economy. Solid wall type abutments shall be provided only in water crossing bridges and at other land structures, normal pier will be proposed with RE wall behind to retain the earth. Abutments shall be provided with Approach slabs as per MORT&H details.

3.12.3 Foundation

Foundations will be with shallow type open foundation for Minor structures and with pile foundation for river bridges, ROBs and flyovers. Necessary soil investigations shall be done. Piles are to be load tested both for initial and routine. All piles shall be tested for integrity.

3.12.4 Design Loads

a) Dead Loads & Super Imposed Dead Loads

Dead load includes self weight of structures and super imposed dead load includes wearing coat, crash barriers, median etc. The weight of wearing coat shall be considered as 200 kg/Sq.m and the weight of crash barrier will be 1 T/m in design.

b) Live Loads

Each four lanes of the structure shall be designed for two lanes of Class A or single lane of Class 70 R loading whichever produces the critical effect. The position of live loads in transverse direction shall be as per Cl 204.1 and Table 6 of IRC: 6. The live load shall be placed in longitudinal direction in such a way that it produces maximum design forces in bearings, sub structure and foundation.

c) Wind forces

Wind forces shall be considered as per Clause 209 of IRC: 6.

d) Seismic Force

The structure shall be designed for appropriate seismic forces as per Flyover shall be designed for appropriate seismic forces as per the provisions of IRC: 6.

The weight of soil likely to be resting on top of the foundation above the general ground level shall be taken into account while computing the seismic forces.

e) Earth Pressure

(i) The soil properties for embankment shall be in accordance with MORT&H specification. The properties of embankment like Dry density of soil 1.85 T/cum, Saturated density 2.00 T/Cum: ø= 30 degree & C=0 shall be considered for design purpose.

(ii) Saturated density of the backfill (minimum 2T/Cum) shall be considered for calculating earth pressure.

(iii) For the soil below water table, submerged density is to be considered in earth pressure calculation. Hydrostatic pressure shall be considered in addition.

(iv) For box type closed structure, earth pressure at rest is to be considered in the analysis.

f) Temperature Range

(i) For design of structure to account for temperature in formula movement (DL) = ΔLt, the value of "t" shall be 25 degree centigrade

Δ = Coefficient of expansion or contraction
L = Length of the member
(DL) = Expansion / contraction due to temperature variation is appropriate units.

(ii) The superstructure shall also be designed for effects of distribution of temperature across the deck depth as per IRC: 6.

3.12.5 Structure Configuration

All the structures for the flyover carriageway shall be designed 16.5m 4 lanes) outer to outer width. The salient structural component of the proposed elevated corridor is given in **Table 3-3**.

Table 3-3 Structural Details of the Flyover

Sl.No.	Span Length	Type of Super Structure	Type of Substructure	Type of Foundation
1	30m to 60m (For Flyover)	Precast twin cell Box Girder Segmental type Construction	Authentically designed rectangular pier and curved in shape after certain height	Pile Socketed into rock

3.12.6 Vertical Clearance

As per IRC: 54 requirements, minimum vertical clearance to be provided between top of surface level load and soffit of girder / slab is 5500 mm in urban areas. The clearances in railway crossing will be 6525 mm above rail level.

3.12.7 Approach Ramp

It is proposed to adopt "Reinforced Earth" type retaining structure for the approach ramp up to 6m height above FGL. The reinforced earth facia wall made of precast concrete panels offers great scope for a variety of aesthetic treatments in the form of panel shapes and colour. Apart from aesthetics, it improves the speed of construction. For heights more than 6m, RCC vertical cantilever type wall will be considered. The wall will be with solid section or with counterforts depends on the heights.

3.12.8 Substructure

(i) RCC solid piers shall be generally as indicated in the drawing.
(ii) Scope for accessibility for inspection of bearings and arrangement for lifting of the superstructure for future replacement of bearings shall be provided for in the design of substructure and superstructure. The positions of flat jacks shall be distinctly marked on the drawing.

3.12.9 Superstructure

a) Deck Slabs

- The minimum thickness of deck slab thickness shall be 200 mm

b) Box Girders

(i) Minimum Web thickness for RCC girders = 250 mm

(ii) Minimum Web thickness for PSC girder = depends on type and diameter of cables as per IRC 112.

However minimum thickness shall also satisfy the provisions of IRC 112.

(iii) The cross diaphragms shall be minimum one number at each support and at ends of cantilever, if any. In addition, at abrupt change in soffit geometry, stiffening frame or diaphragm shall be provided to cater for forces arising out of change in direction.

(iv) Minimum thickness of diaphragms shall be either the thickness of the web at the location or shall be 500 mm from design whichever is greater.

(v) Detailing of structure shall be as per specifications by IRC / MORT&H. Wherever indirect supporting of the structures is adopted, the junction shall be provided with additional reinforcement as prescribed by standards / codes at the junction.

c) PSC Precast girders / Steel composite girders / Bow string girders

The superstructure with PSC girders shall be analysed with two dimensional grillage analysis.

The result of analysis will be considered for the design of main longitudinal girders and diaphragms. The deck slab shall be analysed as a continuous slab supported on longitudinal girder.

d) PSC Precast girders / Steel composite girders / Bow string girders

i) Analysis of structures shall be based on two/three dimensional grillage / three dimensional finite element method of analysis. For straight spans, grillage method of analysis may be adopted and for curved spans, analysis shall be based on finite element method of analysis only. Effect of long-term deformation of diaphragm and consequent redistribution of load in the web shall be duly established and provided for.

ii) Soffit of box shall be kept horizontal and cross slope in deck shall be achieved by varying the web height.

iii) Loads and Load combination to be considered for the design of the box shall be as per Clause 5 of IRC 6.

iv) Reinforcement in the slabs and webs due to the transverse moments must be provided in addition to the steel, which is required for shear or torsion in the box as a main girder in longitudinal direction.

v) Minimum un tensioned reinforcement shall be as per IRC 112. Reinforcement required for traverse bending of box as whole, horizontal cable deviations, etc. shall be provided in deck / soffit slab in addition to the steel required for transverse bending.

vi) In shear calculations (for both maximum shear stress calculations & shear capacities calculations), vertical upward component of pre stress should not be considered in designs for sections cracked in flexure. Sections shall be considered cracked or uncracked based on cracking moment at those sections. Section is considered to be cracked when ultimate moment is more than cracking moment at that section and section is considered to be uncracked if cracking moments is more than ultimate moment at that section.

vii) In maximum shear stress calculations, effective depth should be calculated corresponding to C.G. of pre stressing steel.

viii) If simply supported spans are used, deck continuity shall be properly designed and provided shall to the satisfaction of Engineer in charge. The arrangement shall ensure riding comfort without causing an aesthetic infringement. The webs over the supports shall also be made aesthetically continuous.

e) Pre stressing Steel

i) The pre stressing cables to be used shall be made using low relaxation HT strands conforming to BIS: 14268. Pre-stress of steel if not used within 3 months manufacture, the same shall be tested again before use.

ii) All pre stressed members shall have spare cables laid to the profiles approved by the Engineer, Employer/ Employer's Representative. The number of spare cables shall be at least 5% of the cables required as per design, subject to a minimum of one cable per girder/web. These cables shall be permitted to be removed fully or partly after the final stage of pre stressing, if they are not required and holes grouted.

iii) The maximum permissible jacking force shall be as per clause 7.9.2 of IRC:112

  a) Only approved rigid HDPE sheathing shall be used
  b) Temporary pre stressing shall be done using Bars of approved system
  c) Curved tendons in curved spans shall be detailed as per clause 7.10 of IRC:112
  d) Future pre stressing provisions shall be made wherever possible.

3.13 Material

The material requirement is briefed in the following sections.

(i) Minimum Grade of Concrete:

    a) Pile - M 35 Grade
    b) Pile cap - M35 Grade
    c) Pier - M35 Grade
    d) PSC Super Structure - M45 Grade
    e) RCC Super Structure - M35 Grade
    f) PCC - M15 Grade
    g) Crash Barrier - M40
    h) Approach Slab - M30

(ii) Reinforcement

    a) Fe 500 conforming to IS:1786.

(iii) Condition of Exposure - Moderate

3.14 Bearings below Superstructure

a) Only POT – PTFE bearings manufactured by MORT&H approved manufacturer is acceptable for long span superstructure.

b) The bearings shall be easily accessible for inspection / maintenance.

c) Wherever bearings have to resist uplift force, it shall be of spherical knuckle type and shall be designed as per AASHTO code (Section 14) unless specified otherwise.

d) Scope for lifting the superstructure for future replacement of bearings shall be provided for in the design of bearing. The scheme of lifting shall be indicated on the drawing to be submitted along with the technical bid.

    i) The POT bearings shall conform to the requirements of the MORT&H specifications/IRC 83 Part III. The pots shall be of cast steel of approved grade unless specified otherwise. The minimum thickness of the stainless steel sliding plate shall be 3 mm.
    ii) The dimensions of top plate of bearing shall be such that the contact surface of superstructure projects beyond the edge of bearing plate by a minimum distance of 100 mm at any location.
    iii) All the bearings need to be tested for the acceptance criteria as per the provision of MORTH/ IRC specifications.
    iv) Neoprene elastomeric bearings shall be consideredfor small spans.

3.15 Expansion Joints

Strip seal / Modular type expansion joint conforming to section Clause 2607 of MORT&H Specifications shall only be allowed. Calculations for the adequacy of the type of expansion extent, which is selected by the tenderer, shall be submitted in the Technical bid along with name of manufacturer and their technical details. Expansion joints shall be provided with loop anchors. During installation of these joints, manufacturer's engineer shall be required to supervise the same including thermal presetting, if required. The expansion joint locations shall be carefully treated and harmonized to ensure aesthetics.

3.16 Pre cast Segmental Construction

Following aspects shall be taken into account while designing and constructing using this technique.

a) All segments in a span shall be of precast only and no stitch elements shall be permitted.
b) All the segments shall be long line match-cast.
c) Stressing of cables shall be done from one end only.
d) The shear keys at the face of segments shall be as under:
    i) On each web single key or multiple keys shall be provided as per IRC codal provisions. The decision of Employer/Employer's Representative in respect of numbers of shear keys and areas shall be final.
    ii) On the top and bottom slabs keys shall be provided to maintain alignment and level.
    iii) Total area of shear key provided shall not be less than 20 % of area of cross section of box.
e) Formwork shall be robust and the foundations of the casting and stacking yard shall be designed to safely support all applied loads without undesired deformations or settlements.
f) In order to achieve smooth profile of pre stressing cables and to prevent entry of cement slurry at the joints of matching segments, PVC pipe shall be inserted through the cable duct of both the segments (i.e., matching segment and segment being cast) at the time of concreting.
g) The work shall be executed by specially experienced team of prestressing professionals.
h) Bond breaking agents shall be used while casting the segments so that the segments can be easily separated after casting. Scheme for precasting of segments shall be got approved by the Engineer.
i) The joints between adjacent segments shall be treated with appropriate epoxy formulation to facilitate erection and to fill cavities if any. While applying epoxy, care shall be taken to see that the epoxy does not block the openings of the cable ducts.
j) Epoxy shall be applied on the interface of both the segments and the joint subjected to a minimum pressure of 3.0 Kg/Sq cm. This may be achieved by temporary prestress or

any other approved means. Permanent cables shall then be introduced in the ducts and after prestressing the required number of cables in the specified sequence the temporary prestress may be released.

k) The method of erection of segments shall be such that the desired geometric profile of the Flyover deck is obtained.

l) The segments shall be checked for stresses during handling and erection and necessary calculations submitted for Engineer's approval.

m) Calculation for segment casting dimensions shall be submitted for Engineer's approval taking into account the effect of creep and shrinkage.

n) Only overhead launching without bottom support is acceptable.

o) Reference may be made to the document "Guides to good practice Recommendations for segmental construction in Prestressed Concrete" published by FIB and state of the art report on materials and systems for external prestressing.

3.17 Retaining Walls

Typical cross for the project warrants containing embankment spill within 100 m ROW. This necessitates provision of retaining wall between main road and service road and / or at end of service road. Retaining wall will also be required at approaches of underpass / flyovers.

3.18 Shifting of Utilities

Shifting of utilities shall be taken up prior to the commencement of construction of retaining wall. Prior to the commencement, the contractor will have to co-ordinate the shifting with the respective agency representatives. The same shall be carried out under their direct supervision with minimal disruption of the services.

3.19 Design of Structures

The design of entire structures for the project shall be as per IRC:112. The following are to be considered in the design:

- Load combinations as per IRC:6
- The design of Pier for slenderness effet due to long column behavior is to be as per IRC:112.
- The crack width limitations and deflections shall be as per the provisions in IRC:112.
- The detailing of reinforcement and pre stress cables etc., shall be as per IRC:112 codal provisions.

- The structural members are to be designed for ULS and SLS condition for the stress in concrete and steel within permissible limits.

3.20 Drainage Arrangement

For the provision of adequate drainage of rain water from the viaduct portion, drainage spouts with 50m dia stainless steel drain pipes shall be provided at an interval of 1.5 m c/c on either sides of carriageway in a staggered manner. The water on the earth filled portion shall be allowed to flow over the surface till the cross drain provided at the foot of the grade separator on either side of grade separator and then this water shall be taken to the road side drains through NP3 type RCC pipe of suitable size which shall be laid 600 mm below the road formation level over PCC bedding. The drainage arrangements shall be provided in the landscaping areas as well and then this water shall also be taken to the road side drains through NP3 type RCC pipe of suitable size which shall be laid 600 mm below the road formation level over PCC bedding.

3.21 Surveys and Investigations

The consultant has carried out following surveys and investigations for the project. These are briefly given in following sections.

3.21.1 Traffic Surveys

Traffic surveys were carried out on all major road networks nearer to proposed PRR alignment. Traffic surveys included 3 / 7 days volume counts, Origin Destination surveys and Registration Plate surveys. Details are in given in Section 2 of this report.

3.21.2 Axle Load surveys

Axle load surveys were carried out on existing National Highways nearer to proposed PRR alignment. The survey comprised of measurement of axle loads of commercial vehicles like LCV, 2 axle trucks, 3 axle trucks, multi axle vehicles and buses. Vehicle Damage Factor for various categories of vehicles were computed as per IRC:37. Summary of Vehicle Damage Factor at various locations are given in Pavement design section.

SECTION – 4

PAVEMENT DESIGN

4 PAVEMENT DESIGN

4.1 General

This section describes the design considerations and methodologies adopted for pavement design. For the project, following pavement types are used. They are

- Flexible pavement for main road
- Flexible pavement for service road
- Rigid Pavement for Toll Plaza & its approaches.

The pavement type is finanlised based on detailed discussion with TAC meetings. TAC suggested to adopted flexible pavement instead of rigid pavement earlier proposed.

4.2 Design of Flexible Pavement

Pavement designs for new construction of flexible pavement for main road are in accordance with the latest guidelines given in IRC: 37-2018. Design steps for flexible pavement are given in following sections.

4.2.1 Design Life

Design life of flexible pavement is taken as 20 years as per clause 4.3.1, IRC-37:2018.

4.2.2 Lane Distribution Factor

Lane distribution factor of 0.45 is considered for 4 lane dual carriageway, in accordance with the clause 4.5.1.5, iv IRC: 37-2018 for dual four lane carriageway roads.

4.2.3 Subgrade Strength

Pavement crust is computed for an effective soil CBR value of 10%. At locations, where CBR value is less than 10%, it is proposed to remove existing soil and replace with borrow soil of CBR of greater than 10% and compact to 97% of proctor density.

4.2.4 Traffic Loading

Traffic considered in computation of pavement design is obtained from Annual Average Daily Traffic (AADT) for three homogenous sections separately with corresponding growth rates. Details are given in Table 4-1.

Table 4-1: Design Traffic for Pavement Design

Traffic Loading, PCU			
Year	Section-1	Section-2	Section-3
2019	20559	27740	27875
2022	24237	32378	33002
2027	31554	41502	43362
2032	40392	52445	56220
2037	51057	65655	72105
2042	64065	81794	91614

4.2.5 Vehicle Damage Factor

The consultant had carried out axle load survey in 2019 on existing roads intersecting PRR. Vehicle Damage Factors for commercial vehicles are computed and is presented in Table 4-2.

Table 4-2: Vehicle Damage Factors adopted

Vehicles	Section-1	Section-2	Section-3
LCV	0.904	0.991	0.798
Mini Bus	0.899	0.951	0.962
Bus	0.899	0.951	0.962
2 Axle Truck	3.381	2.560	3.204
3 Axle Truck	4.435	5.181	5.562
MAV	10.895	10.643	10.808

4.2.6 Design Traffic Loading

Design traffic in terms of equivalent million standard axles (EMSA) is computed for diverted traffic and generated traffic separately in spread sheet using AADT and VDF for three sections separately and details are given in Table 4-3, Table 4-4 and Table 4-5 respectively.

Table 4-3: Estimation of EMSA, Section-1

PCU		3	1.5	1.5	3	3	4.5		3	1.5	1.5	3	3	4.5		LDF	0.45		
VDF		0.90	0.90	0.90	3.38	4.44	10.90		0.90	0.90	0.90	3.38	4.44	10.90			0.45		
Year	Operation Period	LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	Grand Total	Total PCU	ESAL	Cum MSA
2019		1057	396	791	1581	1309	1224	6358	226	30	173	66	56	18	569	6927	20559	2	
2020		1142	416	853	1614	1394	1304	6723	236	31	180	68	58	19	592	7315	21710	2	
2021		1234	437	920	1648	1485	1389	7113	246	32	188	70	60	20	616	7729	22935	3	
2022	0	1334	459	992	1683	1582	1479	7529	256	33	196	72	62	21	640	8169	24237	3	3
2023	1	1442	482	1070	1719	1685	1575	7973	267	34	204	74	64	22	665	8638	25625	3	6
2024	2	1547	507	1145	1755	1784	1667	8405	281	36	211	78	66	23	695	9100	26987	3	9
2025	3	1659	533	1226	1792	1888	1765	8863	295	38	218	82	68	24	725	9588	28425	3	12
2026	4	1779	560	1312	1830	1998	1868	9347	310	40	225	86	70	25	756	10103	29943	3	15
2027	5	1908	588	1404	1869	2115	1977	9861	326	42	233	90	72	26	789	10650	31554	3	18
2028	6	2046	618	1503	1908	2239	2093	10407	343	44	241	94	74	27	823	11230	33261	4	22
2029	7	2180	649	1598	1948	2357	2203	10935	360	46	248	98	76	28	856	11791	34908	4	26
2030	8	2322	682	1699	1989	2481	2319	11492	377	48	256	102	78	29	890	12382	36641	4	30
2031	9	2474	717	1807	2031	2612	2441	12082	395	50	264	106	80	30	925	13007	38471	4	34
2032	10	2635	753	1921	2074	2749	2569	12701	414	52	272	111	82	31	962	13663	40392	4	38
2033	11	2807	791	2043	2118	2894	2704	13357	434	54	280	116	84	32	1000	14357	42423	5	43
2034	12	2972	831	2159	2163	3039	2840	14004	453	56	288	120	86	33	1036	15040	44429	5	48
2035	13	3146	873	2282	2208	3191	2982	14682	473	58	296	125	88	34	1074	15756	46529	5	53
2036	14	3331	917	2412	2254	3351	3132	15397	494	60	304	130	90	35	1113	16510	48741	5	58
2037	15	3526	963	2549	2301	3519	3289	16147	515	63	312	135	92	36	1153	17300	51057	6	64
2038	16	3733	1012	2694	2349	3695	3454	16937	537	66	320	140	94	37	1194	18131	53492	6	70
2039	17	3930	1063	2832	2398	3880	3627	17730	558	69	328	145	96	38	1234	18964	55952	6	76
2040	18	4138	1117	2977	2448	4074	3809	18563	580	72	336	150	98	39	1275	19838	58533	6	82
2041	19	4357	1173	3129	2499	4278	4000	19436	603	75	344	155	100	40	1317	20753	61238	7	89
2042	20	4587	1232	3289	2551	4492	4200	20351	626	78	352	160	102	41	1359	21710	64065	7	96

Table 4-4: Estimation of EMSA, Section-2

PCU		3	1.5	1.5	3	3	4.5		3	1.5	1.5	3	3	4.5		LDF	0.45		
VDF		0.991	0.951	0.951	2.560	5.181	10.643		0.991	0.951	0.951	2.560	5.181	10.643			0.45		
Year		LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	Grand Total	Total PCU	ESAL	Cum MSA
2019		995	575	1141	2554	1960	1440	8665	345	47	263	97	82	27	861	9526	27740	3	
2020		1072	604	1235	2609	2086	1533	9139	359	49	274	99	84	28	893	10032	29195	3	
2021		1155	635	1337	2666	2220	1631	9644	374	51	285	101	86	29	926	10570	30738	3	
2022	0	1244	667	1448	2724	2362	1736	10181	389	53	297	104	88	30	961	11142	32378	4	4
2023	1	1340	701	1568	2783	2513	1847	10752	405	55	309	107	90	31	997	11749	34115	4	8
2024	2	1433	737	1685	2843	2658	1954	11310	423	57	322	110	92	32	1036	12346	35816	4	12
2025	3	1533	774	1810	2905	2811	2067	11900	441	59	336	113	94	33	1076	12976	37610	4	16
2026	4	1640	813	1945	2968	2973	2186	12525	460	61	351	116	96	34	1118	13643	39504	4	20
2027	5	1754	854	2090	3032	3144	2312	13186	480	63	366	119	98	35	1161	14347	41502	5	25
2028	6	1876	897	2245	3098	3325	2445	13886	501	65	382	122	100	36	1206	15092	43614	5	30
2029	7	1994	942	2395	3165	3498	2572	14566	520	67	397	125	102	37	1248	15814	45654	5	35
2030	8	2119	990	2555	3234	3680	2706	15284	540	69	413	128	105	38	1293	16577	47807	5	40
2031	9	2252	1040	2726	3304	3871	2847	16040	561	71	429	131	108	39	1339	17379	50067	5	45
2032	10	2393	1092	2908	3376	4072	2995	16836	583	74	446	134	111	40	1388	18224	52445	6	51
2033	11	2543	1147	3102	3449	4283	3151	17675	606	77	463	137	114	41	1438	19113	54944	6	57
2034	12	2686	1205	3289	3524	4498	3309	18511	627	79	479	140	117	42	1484	19995	57434	6	63
2035	13	2837	1266	3487	3600	4723	3475	19388	649	82	496	143	120	43	1533	20921	60044	7	70
2036	14	2997	1330	3697	3678	4960	3649	20311	672	85	513	146	123	44	1583	21894	62784	7	77
2037	15	3166	1397	3919	3758	5208	3832	21280	695	88	531	149	126	45	1634	22914	65655	7	84
2038	16	3344	1467	4155	3839	5469	4024	22298	719	91	550	152	129	46	1687	23985	68666	8	92
2039	17	3513	1541	4380	3922	5743	4226	23325	742	94	567	156	132	47	1738	25063	71726	8	100
2040	18	3691	1619	4617	4007	6031	4438	24403	765	97	585	160	135	48	1790	26193	74931	8	108
2041	19	3878	1700	4867	4094	6333	4660	25532	789	100	603	164	138	49	1843	27375	78284	9	117
2042	20	4074	1785	5130	4183	6650	4893	26715	814	103	622	168	141	50	1898	28613	81794	9	126

Table 4-5: Estimation of EMSA, Section-3

PCU		3	1.5	1.5	3	3	4.5		3	1.5	1.5	3	3	4.5		LDF	0.45		
VDF		0.798	0.962	0.962	3.204	5.562	10.808		0.798	0.962	0.962	3.204	5.562	10.808			0.45		
Year		LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	LCV	Mini Bus	Bus	Two Axle Trucks	Three Axle Trucks	Multi Axle Vehicles	Total, No	Grand Total	Total PCU	ESAL	Cum MSA
2019		706	534	1519	2511	2262	1456	8988	323	38	211	68	58	19	717	9705	27875	3	
2020		782	574	1595	2701	2310	1547	9509	336	40	220	70	60	20	746	10255	29472	3	
2021		866	616	1675	2905	2359	1644	10065	350	42	229	72	62	21	776	10841	31178	4	
2022	0	959	662	1759	3125	2409	1747	10661	364	44	239	74	64	22	807	11468	33002	4	4
2023	1	1062	711	1847	3361	2460	1856	11297	379	46	249	76	66	23	839	12136	34947	4	8
2024	2	1165	758	1940	3590	2512	1960	11925	395	48	260	78	68	24	873	12798	36861	4	12
2025	3	1278	808	2037	3834	2565	2070	12592	412	50	271	80	70	25	908	13500	38894	4	16
2026	4	1402	862	2139	4095	2619	2186	13303	430	52	283	82	72	26	945	14248	41058	5	21
2027	5	1538	919	2246	4374	2674	2309	14060	449	54	295	84	74	27	983	15043	43362	5	26
2028	6	1687	980	2359	4672	2730	2439	14867	468	56	308	86	76	28	1022	15889	45813	5	31
2029	7	1834	1039	2477	4958	2788	2562	15658	486	58	320	88	78	29	1059	16717	48197	5	36
2030	8	1994	1101	2601	5262	2847	2691	16496	505	60	333	90	80	30	1098	17594	50721	6	42
2031	9	2167	1167	2732	5584	2907	2827	17384	525	62	346	92	82	31	1138	18522	53393	6	48
2032	10	2355	1237	2869	5926	2968	2970	18325	545	64	360	94	84	32	1179	19504	56220	6	54
2033	11	2560	1311	3013	6289	3031	3120	19324	566	66	374	96	86	33	1221	20545	59219	6	60
2034	12	2760	1381	3164	6636	3095	3276	20312	586	68	387	98	88	34	1261	21573	62184	7	67
2035	13	2976	1455	3323	7002	3160	3440	21356	606	70	401	100	90	35	1302	22658	65313	7	74
2036	14	3209	1533	3490	7388	3227	3612	22459	627	72	415	102	92	36	1344	23803	68616	7	81
2037	15	3460	1615	3665	7795	3295	3793	23623	649	74	430	105	94	37	1389	25012	72105	8	89
2038	16	3731	1702	3849	8225	3364	3983	24854	672	76	445	108	96	38	1435	26289	75791	8	97
2039	17	3994	1788	4042	8637	3435	4183	26079	693	78	459	111	98	39	1478	27557	79454	8	105
2040	18	4275	1878	4245	9069	3507	4393	27367	715	80	474	114	100	40	1523	28890	83304	9	114
2041	19	4576	1972	4458	9523	3581	4613	28723	737	82	489	117	102	41	1568	30291	87353	9	123
2042	20	4898	2071	4681	10000	3656	4844	30150	760	84	504	120	105	42	1615	31765	91614	10	133

IRC: 37 2018 provides design catalogue for pavement crust for various combinations of subgrade CBR and Design Loading (MSA). However, the maximum value of MSA is limited to 50 MSA, unlike earlier version of the code which provided for pavement thickness upto 150 MSA. In the present design, Pavement thickness of all Layers will be provided for 20 years design life. Stresses and strains are computed for the pavement crust to check within permissible limits. Adopted Design loading for pavement crust and stress – strain computation is given in Table 4-6.

Table 4-6: Adopted Design Loading, MSA

Design Loading	Sections		
	1	2	3
10 years	38	51	54
15 years	64	84	89
20 years	96	126	133
Design load adopted	100	130	135

Service Road is proposed to be designed for 20 MSA.

4.2.7 Pavement Crust

Flexible pavement with following composition is proposed as given in Table 4-7.

Table 4-7: Proposed Pavement Composition

Pavement Composition, mm	Section-1	Section-2	Section-3	Service Road
Stone Matrix Asphalt (SMA) SMA,mm	50	50	50	40
Dense Bituminous Macadam (DBM),mm	115	130	130	75
Wet Mix Macadam (WMM),mm	250	250	250	250
Granular Sub Base (GSB),mm	200	200	200	200
Total,mm	615	630	630	565
Subgrade, CBR >=8%,mm	500	500	500	500

4.2.8 Design Check

Typical calculation for stress and strains are computed for section-1. The selected pavement crust should be checked for stress and strains at critical locations as per clause 3.6.1 of IRC: 37. Pavement should be checked for

- maximum tensile strain at the bottom of the bituminous layer as per Equation 3.4 of IRC: 37-2018 (at 90% reliability level) using formula:

$$\boxed{N_f = 0.5161 * C * 10^{-04}\,[1/\varepsilon_t]^{3.89} * [1/M_{Rm}]^{0.854}}$$

Where, Nf = Fatigue life in number of standard axles =100 MSA (for section 1)

$\epsilon_t =$ Maximum tensile strain at the bottom of the bituminous layer

$M_R =$ Resilient modulus of the bituminous layer =3000Mpa

C= factor to be introduced in fatigue models to take into account the effect of air voids (Va) and volume of bitumen (Vb) , which is given by the following relationships

$$\boxed{C = 10^{M}, \quad \text{and} \quad M = 4.84\left(\frac{Vbe}{Va+Vbe} - 0.69\right)}$$

Va= air voids=3%

Vb= Volume of the bitumen = 13%.

By substituting above values in equation, $\epsilon_t =$ 206 Microstrain

- maximum vertical strain at top of subgrade as per Equation 3.2 of IRC: 37-2018 (at 90% reliability level) using the formula:

$$\boxed{N_R = 1.4100 \times 10^{-08}\,[1/\varepsilon_v]^{4.5337}}$$

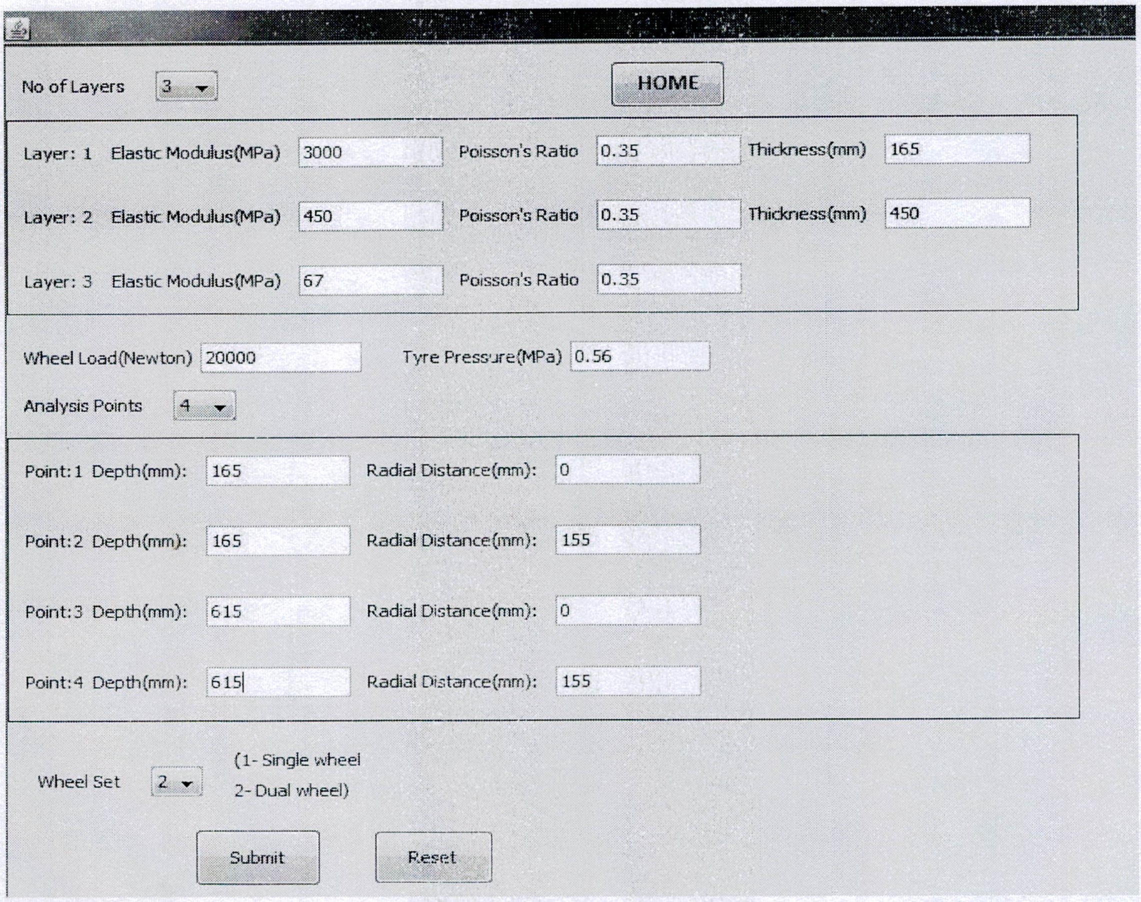
N_R = Number of cumulative standard axles = 100 MSA (for section 1)

$\epsilon_v =$ Vertical compressive strain at the top of the subgrade

$\epsilon_v =$ 319 Microstrain

IITPAVE software is used to compute the stress and strains at critical positions in the pavement and compared with allowable limits for all the three sections. Input parameters for Section 1 is given in Table 4-8 and output result is given in Table 4-9. Table 4-10

Table 4-8: Input for Stress / Strain Computation – Section 1



No of Layers: 3

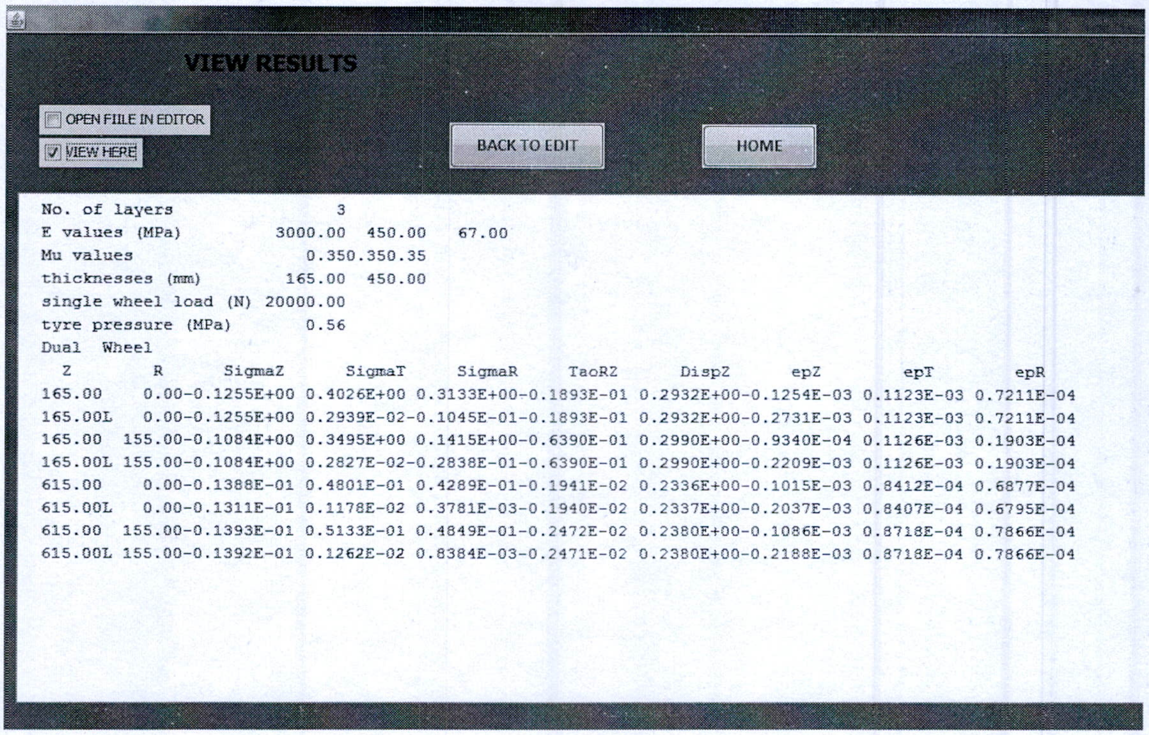
Layer: 1 Elastic Modulus(MPa): 3000 Poisson's Ratio: 0.35 Thickness(mm): 165
Layer: 2 Elastic Modulus(MPa): 450 Poisson's Ratio: 0.35 Thickness(mm): 450
Layer: 3 Elastic Modulus(MPa): 67 Poisson's Ratio: 0.35

Wheel Load(Newton): 20000 Tyre Pressure(MPa): 0.56
Analysis Points: 4

Point:1 Depth(mm): 165 Radial Distance(mm): 0
Point:2 Depth(mm): 165 Radial Distance(mm): 155
Point:3 Depth(mm): 615 Radial Distance(mm): 0
Point:4 Depth(mm): 615 Radial Distance(mm): 155

Wheel Set: 2
(1- Single wheel
2- Dual wheel)

Table 4-9: Results of Stress – Strain Computation – Section 1



```
No. of layers              3
E values (MPa)         3000.00  450.00    67.00
Mu values                 0.350.350.35
thicknesses (mm)        165.00  450.00
single wheel load (N) 20000.00
tyre pressure (MPa)       0.56
Dual  Wheel
  Z         R      SigmaZ      SigmaT     SigmaR     TaoRZ      DispZ      epZ        epT        epR
165.00     0.00-0.1255E+00 0.4026E+00 0.3133E+00-0.1893E-01 0.2932E+00-0.1254E-03 0.1123E-03 0.7211E-04
165.00L    0.00-0.1255E+00 0.2939E-02-0.1045E-01-0.1893E-01 0.2932E+00-0.2731E-03 0.1123E-03 0.7211E-04
165.00   155.00-0.1084E+00 0.3495E+00 0.1415E+00-0.6390E-01 0.2990E+00-0.9340E-04 0.1126E-03 0.1903E-04
165.00L 155.00-0.1084E+00 0.2827E-02-0.2838E-01-0.6390E-01 0.2990E+00-0.2209E-03 0.1126E-03 0.1903E-04
615.00     0.00-0.1388E-01 0.4801E-01 0.4289E-01-0.1941E-02 0.2336E+00-0.1015E-03 0.8412E-04 0.6877E-04
615.00L    0.00-0.1311E-01 0.1178E-02 0.3781E-03-0.1940E-02 0.2337E+00-0.2037E-03 0.8407E-04 0.6795E-04
615.00   155.00-0.1393E-01 0.5133E-01 0.4849E-01-0.2472E-02 0.2380E+00-0.1086E-03 0.8718E-04 0.7866E-04
615.00L 155.00-0.1392E-01 0.1262E-02 0.8384E-03-0.2471E-02 0.2380E+00-0.2188E-03 0.8718E-04 0.7866E-04
```

Stress and strains at critical locations are computed for section 2 and 3 and the summary of results are in Table 4-10.

Table 4-10: Summary of Stress / Strain Computation

CASE	*Section-1*			*Section-2*			*Section-3*		
Critical Stress / Strain	**Design life=20 years VG40**			**Design life=20 years VG40**			**Design life=20 years VG40**		
	SMA=50, DBM=115, G. Base=250, GSB= 200, CBR=8%,			**SMA=40, DBM=130, G. Base=250, GSB= 200, CBR=8%,**			**SMA=40, DBM=130, G. Base=250, GSB= 200, CBR=8%,**		
	MSA=100, Reliability= 90%			MSA=130, Reliability= 90%			MSA=135, Reliability= 90%		
	Allowable Limits (IRC-37-2018)	**Computed Value (IIT-Pave)**	**Remarks**	**Allowable Limits (IRC-37-2018)**	**Computed Value (IIT-Pave)**	**Remarks**	**Allowable Limits (IRC-37-2018)**	**Computed Value (IIT-Pave)**	**Remarks**
Horizontal tensile strain in bituminous layer	206	112.30	***Safe***	193	105.00	***Safe***	191	105.00	***Safe***

CASE	*Section-1*			*Section-2*			*Section-3*		
Vertical compressive strain on subgrade	319	218.80	***Safe***	301	205.40	***Safe***	299	205.40	***Safe***

Computed strains using IIT -Pave software are less than the Maximum allowable strains, hence the selected pavement composition is safe. The input and output window for the IIT-pave for all sections are attached with this document. The maximum allowable strains for section-2 and section-3 can be worked out as above.

4.3 Cement Concrete Pavement

Rigid pavement is proposed at toll plaza and its approaches. Pavement Design for CC pavement is carried out in accordance with IRC:58-2015 and step-wise procedure is given as follows:

a) The basic design parameters are assumed as given in Table 4-11.

Table 4-11: Parameters used in CC Pavement Design

Sl No	Parameter	Value	Unit	Remarks
1	Design Life	30	Years	
2	Subgrade CBR (Effective)	8	%	Select soil
3	Modulus of Subgrade Reaction	48	Mpa/m	Table 2, IRC:58
4	Thickness of Granular Sub Base	150	mm	
5	Thickness of Dry Lean Concrete	150	mm	
6	Modulus of Subgrade Reaction for DLC	277	Mpa/m	Table 4, IRC:58
7	Modulus of Elasticity of Concrete, E	30000	MPa	Clause 5.8.4.1, IRC:58
8	Poisson's Ratio, μ	0.15		Clause 5.8.4.1, IRC:58

Sl No	Parameter	Value	Unit	Remarks
9	Coefficient of Thermal Expansion, α	$10x10^{-6}$		Clause 5.8.5, IRC:58
10	Unit weight of Concrete, Y	24	Kn/Cum	
11	Compressive strength of concrete, f_{ck}	40	Kn/Cum	
12	Flexural Strength of Concrete (28 days), f_{cr}	4.5	MPa	Clause 5.8.4.1, IRC:58
13	Flexural Strength of Concrete (90 days), f_{cr}	4.95	MPa	Clause 5.8.4.1, IRC:58
14	Max Daily Temperature, Δt	21	°C	Table 1, IRC:58
15	Night Time Temperature, Δt	15.5	°C	Clause 6.9.1, IRC:58
16	Load Transfer Efficiency Factor, β	0.66		Appendix - V

b) The loading spectrums at each of axle load location are compiled into single axle and tandem axle for all commercial vehicles applicable. They are further grouped into various load groups. The higher of the axle loads in terms of the frequency is considered in further analysis for fatigue computation.

c) The modulus of subgrade reaction at subgrade for effective subgrade CBR is computed. Modulus of subgrade reaction K is computed using Table-2, clause 5.7.3.4 of IRC:58.

d) Since, granular subbase and dry lean concrete is also proposed as part of the pavement crust, the modulus of subgrade reaction should be considered based on combined action of granular subbase and DLC. However, K value at subgrade corresponding to DLC is only considered in the analysis as per clause 5.7.4.4 and computed as per Table-4, IRC:58 is used in the analysis.

e) The design traffic for each homogenous section for commercial vehicles are projected upto design life. The design traffic is considered as 50% of the total traffic in both the directions, which is ascertained from traffic studies and analysis.

f) The total numbers of axles are computed and the sum product of the commercial vehicles upto design life and corresponding axle configuration. For ex. three axle truck consist of 1 front axle and 2 rear axles in tandem.

g) Number of single steering axles, single axles with dual wheel assembly on both sides and tandem axles are computed from the vehicular category.

h) The total traffic for bottom up cracking (BUC) is considered as 25% of the total traffic in predominant direction taking into account the lateral placement of load as per clause 5.5.2.3 of IRC:58.

i) The night time traffic (usually between 10 PM to 3AM) is considered as 60% of the total traffic. Balance traffic is considered as day time traffic loading. The total traffic considered for Bottom Up Cracking is considered as 50% of the day time traffic.

j) Proportion of commercial vehicles for which the distance between the front and rear axle is less than or equal to 4.5m is computed. The design load repetitions are computed as the proportion of commercial vehicles whose axle spacing is less than 4.5m for six hour night time traffic. This traffic is considered for Top Down Cracking.

The load from measurement of wheel load is converted to axle load and grouped them in size of 10 KN. The loading is further categorized into Single Axle, Tandem axle and Tridam axle. Abstract of the axle load group at various locations for left and right carriageway is given in Table 4-12.

Table 4-12: Abstract of Loading Spectrum

Axle Load Location /Direction : LHS	Tumkur Road			Doddaballapur Road			Bellary Road			Old Madras Road			Hosur Road		
Load Group, KN	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone
0-10	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
10-20	10	2	0	0	0	0	5	0	0	5	0	0	9	0	0
20-30	33	11	0	7	4	1	6	0	0	21	7	0	115	88	4
30-40	74	15	0	37	14	4	23	5	0	38	12	0	188	382	11
40-50	178	14	0	78	6	5	108	2	1	130	14	2	309	79	8
50-60	221	28	0	125	14	6	130	7	0	186	13	0	75	17	3
60-70	93	46	3	66	18	9	57	8	2	143	37	5	219	20	1
70-80	37	43	3	41	52	28	53	14	4	48	69	4	32	10	0
80-90	27	84	2	26	49	26	17	30	6	30	149	3	12	38	1
90-100	32	155	6	18	48	21	18	45	9	23	167	2	7	35	1
100-110	32	187	15	12	70	20	13	90	10	21	132	4	11	167	16
110-120	20	109	9	8	73	14	9	81	6	17	70	3	9	120	14
120-130	7	21	0	0	26	7	4	37	5	2	15	1	0	102	13
130-140	6	15	3	0	10	1	2	18	5	2	7	0	0	17	3
140-150	5	3	1	0	4	1	0	2	0	1	1	0	0	4	2
150-160	2	3	0	0	4	1	1	1	0	0	0	0	0	0	0
160-170	3	2	0	1	0	0	0	0	0	0	1	0	0	0	0
170-180	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
180-190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190-200	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
200-210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210-220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220-230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230-240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240-250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260-270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	780	**740**	**42**	**419**	**392**	**144**	**446**	**340**	**48**	**668**	**695**	**24**	**986**	**1080**	**78**
Load Group, KN	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone	Single Axle	Tandem + Tridum Axle	Tridem Axle Alone
Load Group, KN	Single Axle	Tandem Axle	Tridem Axle	Single Axle	Tandem Axle	Tridem Axle	Single Axle	Tandem Axle	Tridem Axle	Single Axle	Tandem Axle	Tridem Axle	Single Axle	Tandem Axle	Tridem Axle
0-10	0	0	0	1	0	0	1	0	0	9	0	0	1	0	0
10-20	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
20-30	4	2	0	13	8	3	8	0	0	7	9	0	11	1	0
30-40	16	8	0	110	43	6	22	6	1	27	10	0	31	50	0
40-50	114	7	0	127	17	2	124	2	2	107	5	0	73	11	0
50-60	205	9	0	122	12	3	162	4	1	138	5	0	252	6	0
60-70	143	13	1	41	8	5	47	6	1	124	11	0	238	4	0
70-80	47	35	1	26	8	6	43	8	3	46	46	0	204	7	1
80-90	24	95	0	19	20	1	28	37	17	33	124	4	46	17	4
90-100	16	199	0	13	30	3	17	55	15	15	163	2	32	47	4
100-110	19	234	3	16	65	5	11	98	6	10	128	2	37	216	10
110-120	12	99	4	12	50	7	5	85	11	4	70	1	22	321	7
120-130	11	38	0	5	20	11	2	45	15	1	18	1	11	132	1
130-140	5	12	0	3	4	2	1	31	16	2	10	2	13	76	0
140-150	3	4	0	3	1	0	0	4	2	1	2	0	8	7	0
150-160	2	6	0	0	0	0	0	1	0	0	0	0	1	2	0
160-170	2	2	0	0	0	0	0	0	0	0	1	0	0	0	0
170-180	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
180-190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190-200	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
200-210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210-220	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
220-230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230-240	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
240-250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260-270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	623	**763**	**9**	**513**	**286**	**54**	**471**	**382**	**90**	**525**	**602**	**12**	**980**	**899**	**27**

4.4 Design of Dowel Bar System

Load stresses at edge and corner regions of the slab at transverse joints are relieved by means of load transfer devises in the form of dowel bar. Dowel bar system required is computed in accordance with clause 7.2.1 of IRC:58.

4.5 Design of Longitudinal Joints

Longitudinal joints are provided in CC pavement to allow transverse cracking and warping. Design is carried out in accordance with Section 8 of IRC:58.

The design is calculated in MS Excel spreadsheet as per the guidelines given in IRC:58 and details given in soft form as part of the code. The pavement thickness is assumed and total cumulative fatigue life consumed for Bottom Up Cracking and Top Down Cracking is checked to be less than 1. In case, the fatigue life is more than 1, the pavement thickness is increased to limit the fatigue life less than 1.

4.5.1 Summary of flexible pavement design

Summary of the flexible pavement design for main road are as follows:

- Stone Matrix Asphalt with modified binder - 50mm
- Dense Bituminous Macadam - 115mm, 130mm,130mm
- Wet Mix Macadam - 250mm
- Granular Sub Base - 200mm
- CBR of the 500mm of subgrade - 8% (Minimum)
- CBR of soil below the 500mm of subgrade - 5% (Minimum)

4.5.2 Summary of rigid pavement design

- M40 Concrete Pavement Thickness (PQC) = 300mm
- DLC Thickness = 150mm (debonding layer 200 micron polythene sheet in between)
- GSB Thickness = 150mm
- Dowel Bar Dia = 38mm
- Length of Dowel bar(plain) = 500mm
- Spacing of Dowel bar(plain) = 300mm
- Tie Bar Dia (deformed) = 12mm
- Length of Tie bar (deformed) = 580mm
- Spacing of Tie bar (deformed) = 370mm

- Size of Panel = 3500mmX4500mm

4.6 Service Road

Service road is designed for loading of 20MSA and effective subgrade CBR is taken as 8%.The summary of the pavement composition is as follows

- Stone Matrix Asphalt (SMA) : 40mm
- Dense Bituminous Macadam (DBM) : 75 mm
- Wet Mix Macadam (WMM) : 250 mm
- Granular Subbase (GSB) : 200 mm
- CBR of the 500mm of the subgrade from borrow pits = 8%CBR (Minimum)
- CBR of soil below the 500mm of the subgrade = 5% CBR (Minimum)

-----xxxxx-----

SECTION – 5

CROSS DRAINAGE STRUCTURES

5 CROSS DRAINAGE STRUCTURES

5.1 General

The proposed PRR is a green field project, its alignment passing through mix of agricultural and developed areas. The alignment crosses natural streams / water course / nallah. This report covers the following:

- Brief methodology followed for carrying out hydraulic design for the construction of small bridges and culverts across various nallah along the proposed alignment.
- Hydrological and hydraulic study to determine the required size of the drainage structures to allow the estimated design flow.

5.2 Hydraulic Designs - General Design Basis

Hydraulic designs for cross drainage structures are carried out based on guidelines given in following IRC codes of practice:

- IRC:SP:13-2004 - Guidelines for the design of small bridges and culverts.
- IRC:SP:42-2014 - Guidelines for the road drainage.
- IRC:SP:50-2013 - Guidelines for urban drainage.

The design of the drainage system involves (i) calculating the total discharge that the cross drainage structure will require to drain off (Hydraulic analysis) and (ii) fixing the slope and dimensions of the cross drainage structures to have adequate capacity to carry the discharge and afford proper maintenance.

For small water sheds not exceeding 25Km2, the rational method is widely used for estimating the peak run off rates. The rational method is an universally accepted procedure which is based on empirical formulae relating rainfall to runoff. The method is widely used due to simplicity. The formulae is

Q=0.028 x P x A x Ic....................................Equation 5-1

Where,

- Q= Design peak runoff rate in m3/sec.
- P= Co-efficient of runoff for catchment characteristics.
- A= Area of catchment in hectares.
- Ic= Critical intensity of rainfall in cm per hour for the selected frequency and the duration.

Suggested values of runoff coefficient as per clause 4.7.7 of IRC SP-13 (2004) is given in Table 5-1.

Table 5-1: Runoff coefficients for various types of strata

Sl. No.	Type of surface	Runoff Coefficient
1	Steep, bare rock and also city pavements	0.9
2	Rock, steep but wooded	0.8
3	Plateaus, lightly covered	0.7
4	Clayey soils, stiff and bare	0.6
5	Clayey soils, stiff and bare lightly covered	0.5
6	Loam, lightly cultivated or covered	0.4
7	Loam, lightly cultivated or covered largely cultivated	0.3
8	Sandy soil, light growth	0.2
9	Sandy soil, light growth covered, heavy brush	0.1

5.2.1 Critical and Design Intensity (i):

The critical intensity for a catchments is that maximum intensity which can occur in a time interval equal to the concentration time 't' of the catchments during the severest storm (in the region) of a given frequency 'i'. Since each catchment has its own 't', it will have its own 'i'.

$i=(F/T)\{(T+1)/(t+1)\}$.................................... Equation 5-2

Where,

- i=Intensity of rainfall within a shorter period of 't' hours within a storm.
- F=Total rainfall in a storm in cm falling in duration of storm of 'T' hours.
- T=Duration of total rainfall (F) in hours
- t=Smaller time interval in hours within the storm duration of 'T' hours.

Rainfall intensity chosen for the design depends on category and importance of the road section as per clause 7.1.4 of IRC:SP:42-2014, road category of NH and above should be designed by considering 50 year rainfall intensity (50 year one hour maximum rainfall). Flood estimation report, prepared jointly by CWC, MORTH, IMD and DRDO and published by Central Water Council (CWC) for different sub zones in India is shown in Figure 5-1. Bangalore comes under Kaveri Basin Sub-Zone 3(i).

Iso-Pluvial map for 50 Year-24 Hour Rainfall published in Flood estimation report for Kaveri Basin Sub Zone-3(i) is shown in Figure 5-2. Time distribution for 50 Year 7hour Areal Rainfall is shown in Figure 5-3. The rainfall occurred in a watershed is not same over the whole watershed. It may be low in a part of watershed and high in other part of watershed and therefore, this should affect the runoff. To account this in the designs a conversion factor known as Areal Spread Factor is derived from a graph represented in IRC:SP:42-2014 which is shown in Figure 5-4.

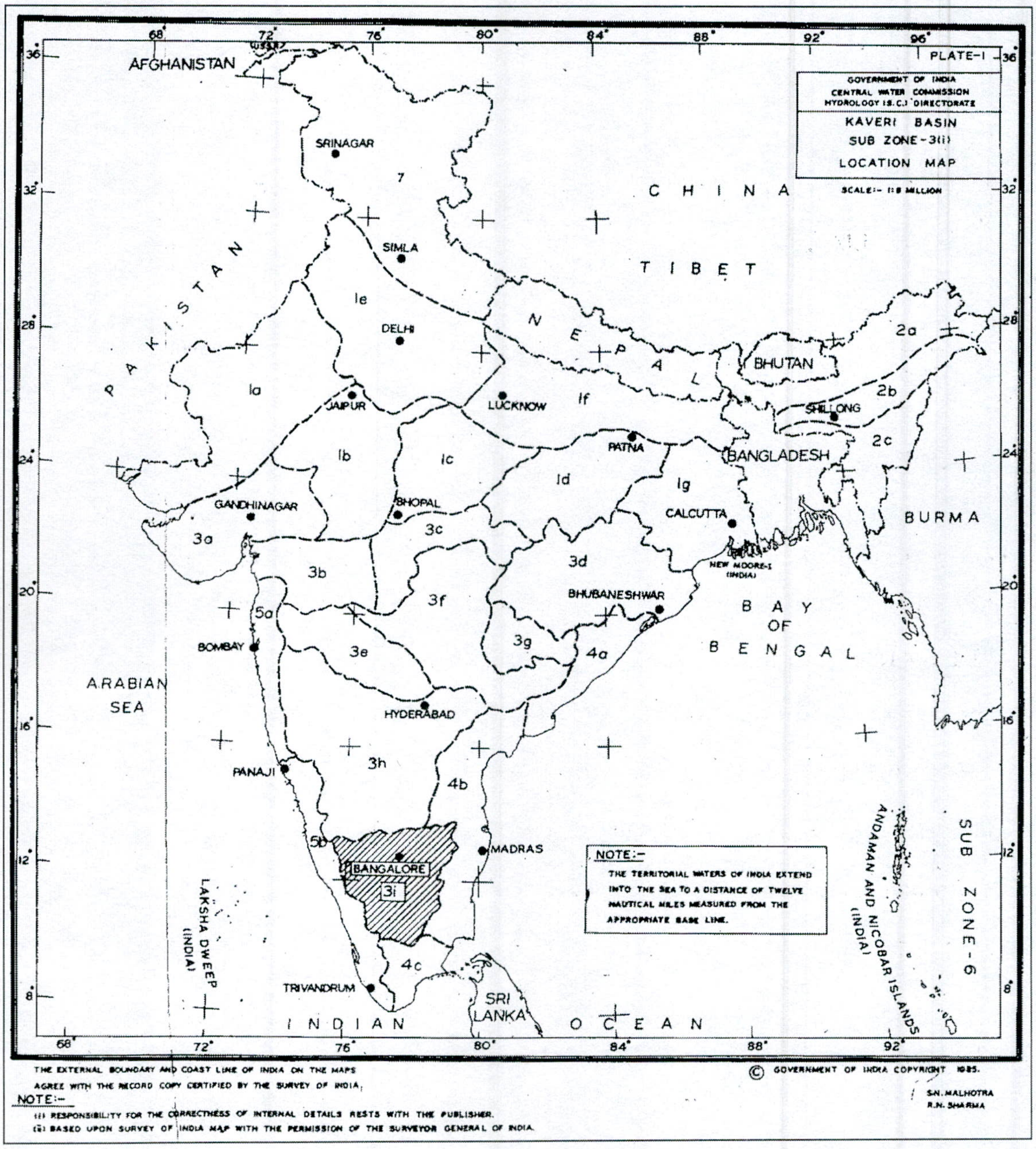


PLATE-I
GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
HYDROLOGY (S.C.) DIRECTORATE
KAVERI BASIN
SUB ZONE-3(i)
LOCATION MAP
SCALE:- 1:8 MILLION
68° 72° 76° 80° 84° 88° 92° 96°
36° 32° 28° 24° 20° 16° 12° 8°
AFGHANISTAN
PAKISTAN
CHINA
TIBET
NEPAL
BHUTAN
BANGLADESH
BURMA
SRI LANKA
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
LAKSHA DWEEP (INDIA)
ANDAMAN AND NICOBAR ISLANDS (INDIA)
SUB ZONE-6
SRINAGAR
SIMLA
DELHI
JAIPUR
LUCKNOW
PATNA
SHILLONG
GANDHINAGAR
BHOPAL
CALCUTTA
NEW MOORE-I (INDIA)
BHUBANESHWAR
BOMBAY
HYDERABAD
PANAJI
MADRAS
BANGALORE
TRIVANDRUM
7
1a 1b 1c 1d 1e 1f 1g
2a 2b 2c
3a 3b 3c 3d 3e 3f 3g 3h 3i
4a 4b 4c
5a 5b
NOTE:-
THE TERRITORIAL WATERS OF INDIA EXTEND INTO THE SEA TO A DISTANCE OF TWELVE NAUTICAL MILES MEASURED FROM THE APPROPRIATE BASE LINE.
THE EXTERNAL BOUNDARY AND COAST LINE OF INDIA ON THE MAPS AGREE WITH THE RECORD COPY CERTIFIED BY THE SURVEY OF INDIA.
NOTE:-
(1) RESPONSIBILITY FOR THE CORRECTNESS OF INTERNAL DETAILS RESTS WITH THE PUBLISHER.
(2) BASED UPON SURVEY OF INDIA MAP WITH THE PERMISSION OF THE SURVEYOR GENERAL OF INDIA.
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S.N. MALHOTRA
R.N. SHARMA

Figure 5-1: Map of India showing Sub-Zones and State Boundaries

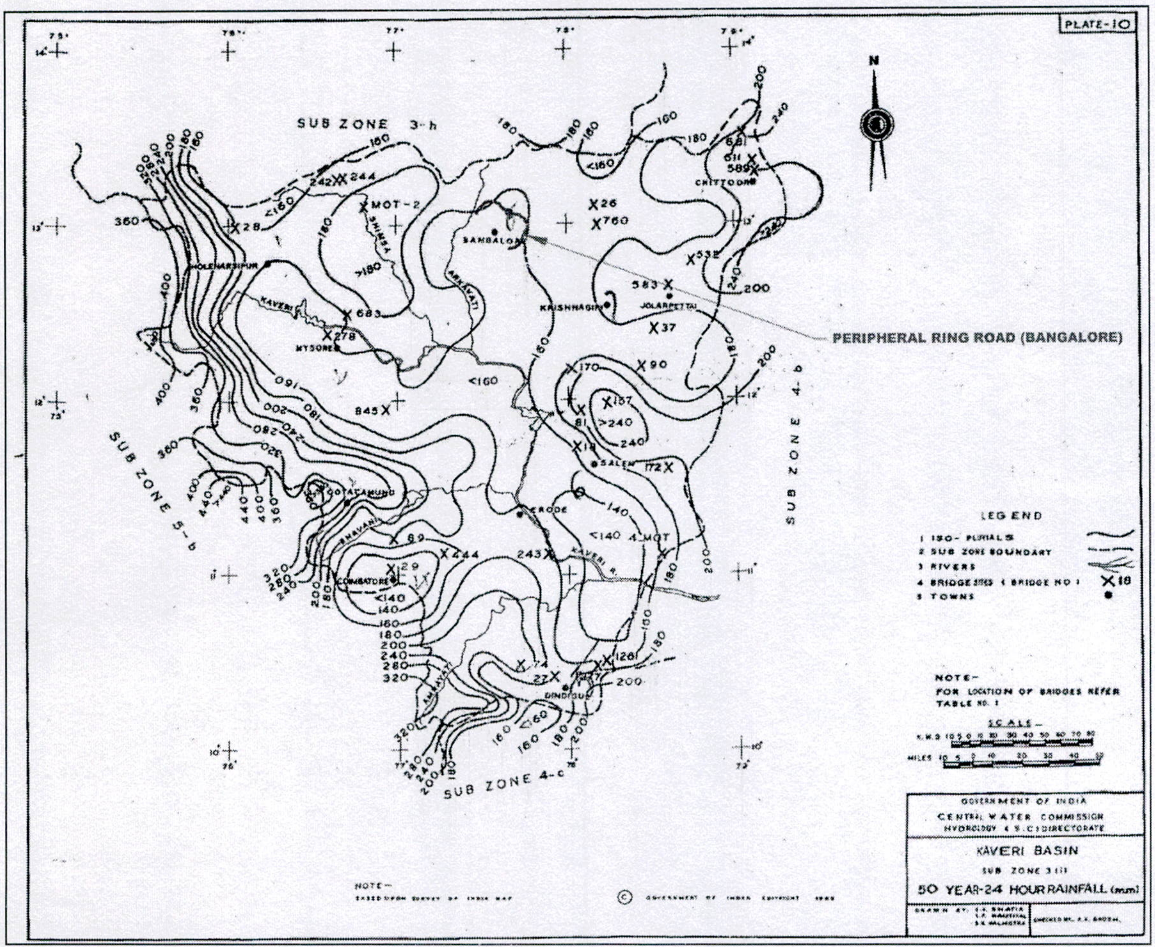
PLATE-10
N
SUB ZONE 3-h
SUB ZONE 4-b
SUB ZONE 5-b
SUB ZONE 4-c
BANGALORE
KRISHNAGIRI
JOLARPETTAI
CHITTOOR
MYSORE
KAVERI
KOLLEGAL
OOTACAMUND
BHAVANI
COIMBATORE
ERODE
SALEM
DINDIGUL
ARKAVATI
MOT-2
4-MOT
PERIPHERAL RING ROAD (BANGALORE)
LEGEND
1 ISO- PLUVIALS
2 SUB ZONE BOUNDARY
3 RIVERS
4 BRIDGE SITES (BRIDGE NO)
X18
5 TOWNS
NOTE-
FOR LOCATION OF BRIDGES REFER TABLE NO. 1
SCALE-
K.M.S 10 5 0 10 20 30 40 50 60 70 80
MILES 10 5 0 10 20 30 40 50
GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
HYDROLOGY & S.C DIRECTORATE
KAVERI BASIN
SUB ZONE 3 (i)
50 YEAR-24 HOUR RAINFALL (mm)
NOTE-
©

Figure 5-2: 50 Year-24 Hour Rainfall (mm)- Kaveri Basin Sub Zone 3(i)

Duration (hrs.)	Distribution Co-efficients	Areal Storm rainfall (cm)	1-hr. rainfall (cm)
(1)	(2)	(3)	(4)
7	1.00	10.23	0.31
6	0.97	9.92	0.30
5	0.94	9.62	0.52
4	0.89	9.10	0.61
3	0.83	8.49	0.82
2	0.75	7.67	1.33
1	0.62	6.34	6.34

Figure 5-3: Time distribution of Areal Rainfall (50 Year 7 hour Rainfall)

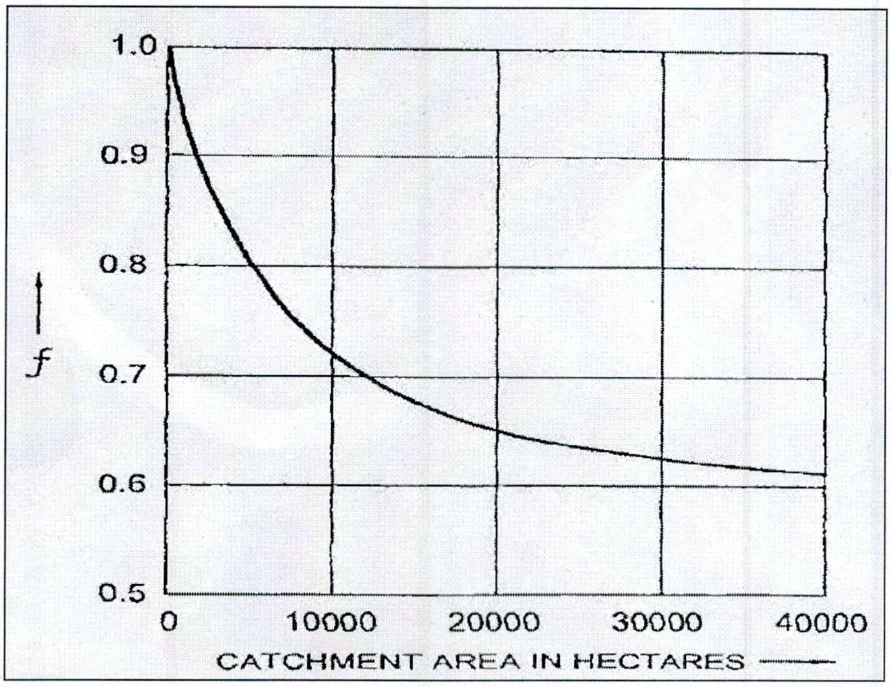

Figure 5-4: Arial Spread Factor v/s Catchment Area

5.2.2 Time of Concentration

It is the time required for maximum runoff rate to develop. It is equal to the time required for a drop of water to run from the most remote point of the road surface to the point for which the runoff is being estimated. Empirical formula given in IRC:SP:13-2004 is used to determine the time of concentration which is shown below:

$T_c=\{0.87\times(L^3/H)\}^{0.385}$....................................Equation 5-3

Where,

- T_c = Time of concentration in hours
- L=Distance of critical point to the cross drainage structure, in Km
- H=Fall in level from the critical point to the drain level in meters

5.3 Hydraulic design of culverts

Once the quantity of runoff is determined, hydraulic design of culvert is carried by estimating the drain capacity using Manning's formula.

$Q = A \times V$....................................Equation 5-4

Where,

V= (1/n) x R2/3 x S1/2....................................Equation 5-5

Q= (1/n) x A x R2/3 x S1/2....................................Equation 5-6

Where,

- Q= discharge in cum/sec
- V=Mean velocity in m/sec
- n=Manning's roughness coefficient
- R=Hydraulic radius in m which is area of flow cross section divided by wetted perimeter.
- S=Longitudinal gradient of culvert
- A=Area of the flow cross-section in m2

The coefficient of roughness for various surfaces are given in IRC:SP:42-2014 is used to adopt manning's coefficient (ref Table 5-2).

Table 5-2: Suggested values of Manning's coefficient (n)

Sl. No.	Type of surface	value of 'n'
1	Brick pitched Drain	0.017
2	Plastered Brick Drain	0.015
3	Plastered brick surface with near cement finish	0.013
4	concrete pipes upto 600mnm dia	0.015
5	concrete pipes above 600mnm dia	0.013
6	Dry rubble masonry	0.033
7	Dressed Ashlar surface	0.015
8	Dry stone pitching	0.020
9	Kutcha Drain	0.025

5.3.1 Vertical Clearance

Minimum vertical clearance for cross drainage structure as per clause 12.3, IRC:SP:13-2004 is shown in Table 5-3.

Table 5-3: Vertical clearance details for CD structure

Discharge in m3/sec	Minimum vertical clearance, m
Upto 0.3	0.150
0.3 to 3	0.450
3 to 30	0.600
30 to 300	0.900
300 to 3000	1.200
Above 3000	1.500

5.4 Design steps of hydraulics calculation

Following are the considerations made in the culvert hydraulics calculation.

- Collection of Topo-sheets for the particular project.
- Identify the streams or nallah for which the cross drainage structure is proposed superimposed on PRR alignment.
- Mark the catchment area on Topo sheet. The catchment area (A) is expressed in hectares.
- On the toposheet, the remotest point or farthest point of the particular catchment is identified. The distance upto the proposed cross drainage structure is measured {Distance (L) expressed in KM}.
- The fall in level (H) between the farthest point and at cross drainage structure is calculated.
- The time of concentration (Tc), using the above Equation 5-3 is computed.
- Next step is to evaluate the Critical intensity of rainfall (i). One hour highest rainfall for return period of 50 years is arrived using (Figure 5-2 and Figure 5-3). For Bangalore region one hour maximum rainfall shall be 100mm/1 hr. Discharge for particular catchment is estimated by a rational method using Equation 5-1.
- Next step is to assess the vent way size for the cross drainage structure. Using manning's formula (Equation 5-4), the capacity of the cross drainage structure is calculated and vent way size (Breadth and Height, height shall be inclusive of vertical clearance), roughness coefficient (n, from Table 5-2), Longitudinal slope (S) is selected. Discharge is calculated using Equation 5-4. The calculated discharge should be more than the generated discharge for the particular catchments. Otherwise, the hydraulic particulars of cross drainage structure are varied until calculated discharge (vent way size, longitudinal slope) greater than generated discharge.

5.5 Hydraulics calculations and Recommended CD structures

The summary of the hydrological and hydraulic calculations of all the Nallahs are given in Table 5-4 and Table 5-5.

Catchment area details for few cross drainage structures are shown from Figure 5-5 to Figure 5-7 and proposed land use plan is given in Figure 5-8.

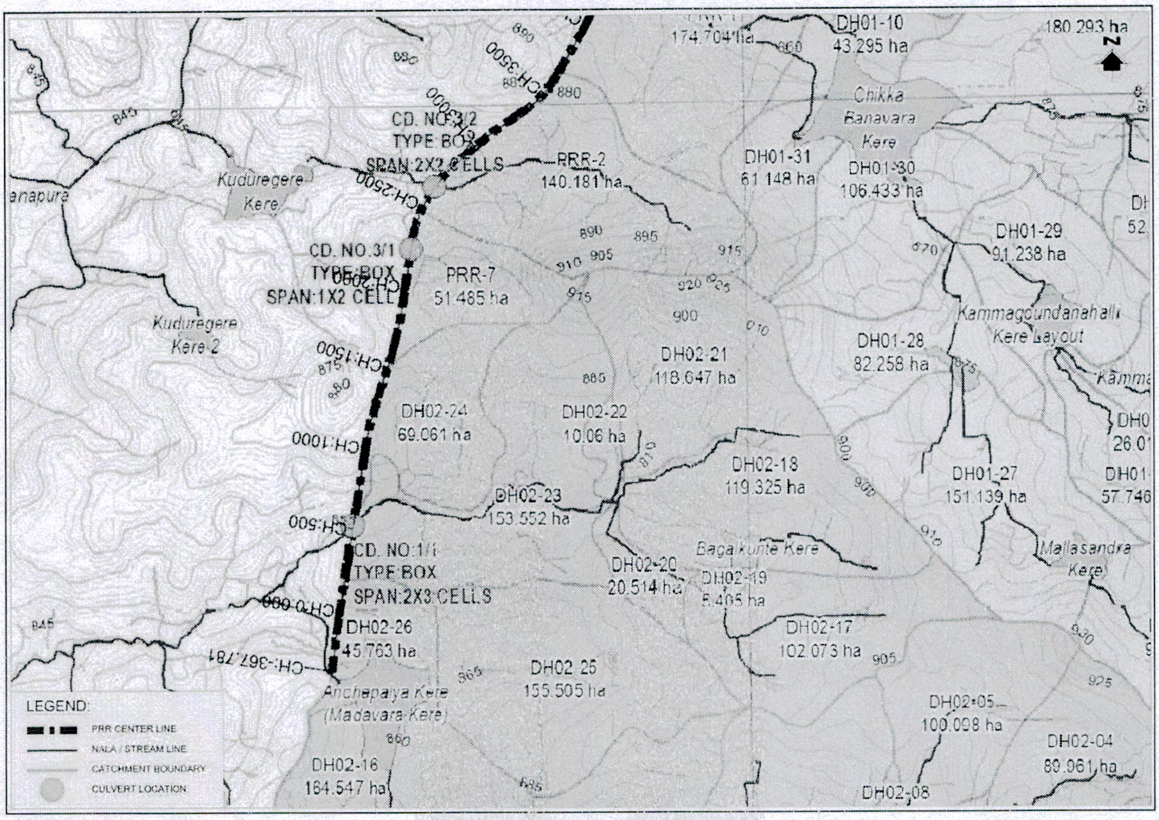
CD. NO:2/2
TYPE BOX
SPAN:2X2 CELLS
CD. NO.3/1
TYPE:BOX
SPAN:1X2 CELL
CD. NO:1/1
TYPE BOX
SPAN:2X3 CELLS
CH:3500
CH:2500
CH:1500
CH:1000
CH:500
CH:0.000
CH:-367.781
PRR-2
140.181 ha
PRR-7
51.485 ha
Kuduregere Kere
Kuduregere Kere-2
DH01-10
43.295 ha
174.704 ha
180.293 ha
Chikka Banavara Kere
DH01-31
61.148 ha
DH01-30
106.433 ha
DH01-29
91.238 ha
Kammagondanahalli Kere Layout
DH01-28
82.258 ha
DH02-21
118.647 ha
DH02-24
69.061 ha
DH02-22
10.06 ha
DH02-18
119.325 ha
DH01-27
151.139 ha
DH02-23
153.552 ha
Bagalkunte Kere
Mallasandra Kere
DH02-20
20.514 ha
DH02-19
5.405 ha
DH02-17
102.073 ha
DH02-26
45.763 ha
DH02-25
155.505 ha
Anchepalya Kere (Madavara Kere)
DH02-05
100.098 ha
DH02-04
89.061 ha
DH02-16
164.547 ha
DH02-08
N
LEGEND:
PRR CENTER LINE
NALA / STREAM LINE
CATCHMENT BOUNDARY
CULVERT LOCATION

Figure 5-5: Catchment area details for CD structures C1 to C3

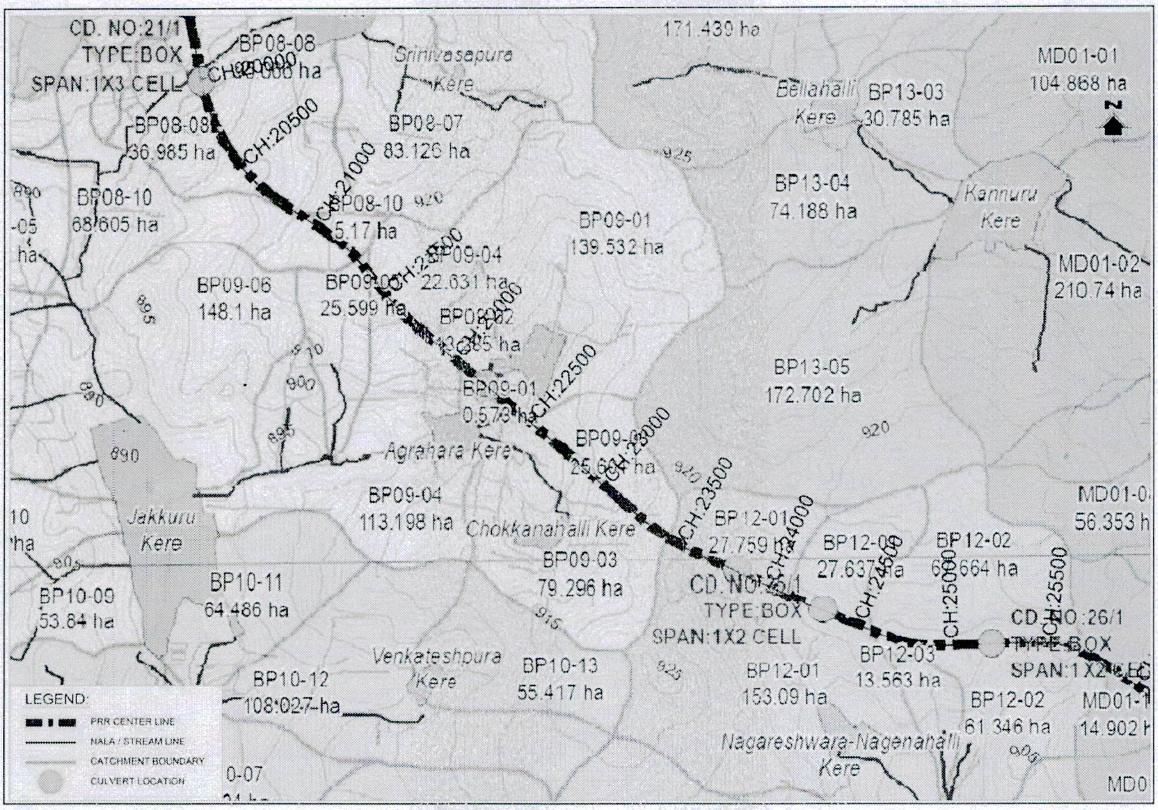
CD. NO:21/1
TYPE:BOX
SPAN:1X3 CELL
CH:20500
CH:21000
CH:22500
CH:23000
CH:23500
CH:24000
CH:25000
CH:25500
BP08-08
BP08-08
36.985 ha
BP08-07
83.129 ha
Srinivasapura Kere
171.439 ha
Bellahalli Kere
BP13-03
30.785 ha
MD01-01
104.868 ha
BP08-10
68.605 ha
BP08-10
5.17 ha
BP09-04
22.631 ha
BP09-01
139.532 ha
BP13-04
74.188 ha
Kannuru Kere
MD01-02
210.74 ha
BP09-06
148.1 ha
BP09-02
25.599 ha
BP09-01
0.573 ha
BP09-03
25.68 ha
BP13-05
172.702 ha
Agrahara Kere
BP09-04
113.198 ha
Chokkanahalli Kere
Jakkuru Kere
BP12-01
27.759 ha
BP12-02
27.637 ha
BP12-02
69.664 ha
MD01-0
56.353 h
BP09-03
79.296 ha
CD. NO:25/1
TYPE:BOX
SPAN:1X2 CELL
CD. NO:26/1
TYPE:BOX
BP10-09
53.84 ha
BP10-11
64.486 ha
BP12-01
153.09 ha
BP12-03
13.563 ha
BP12-02
61.346 ha
MD01-1
14.902 h
Venkateshpura Kere
BP10-12
108.027 ha
BP10-13
55.417 ha
Nagareshwara-Nagenahalli Kere
N
LEGEND:
PRR CENTER LINE
NALA / STREAM LINE
CATCHMENT BOUNDARY
CULVERT LOCATION

Figure 5-6: Catchment area details for CD structures C17 to C21

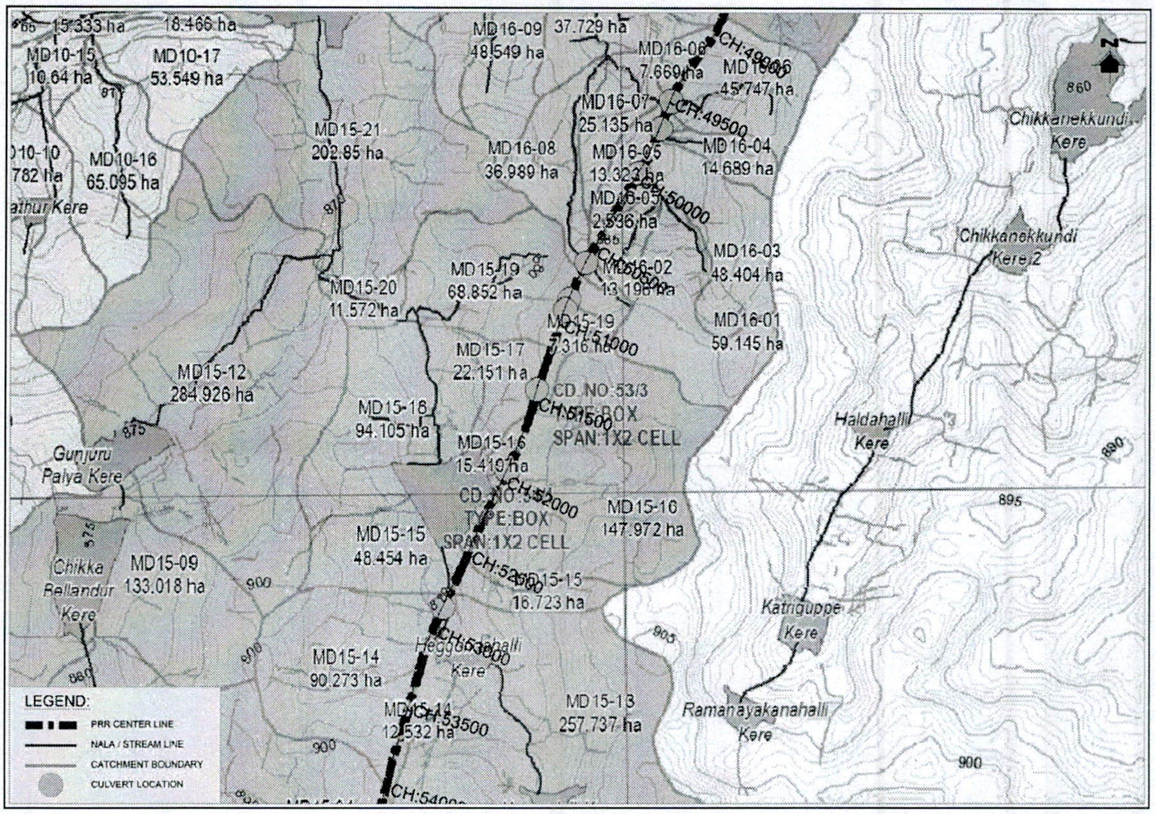
LEGEND:
PRR CENTER LINE
NALA / STREAM LINE
CATCHMENT BOUNDARY
CULVERT LOCATION
MD15-21
202.85 ha
MD15-12
284.926 ha
MD15-20
11.572 ha
MD15-19
68.852 ha
MD15-17
22.151 ha
MD15-16
94.105 ha
MD15-15
48.454 ha
MD15-14
90.273 ha
MD15-13
257.737 ha
MD15-09
133.018 ha
MD16-08
36.989 ha
MD16-09
48.549 ha
MD16-03
48.404 ha
MD16-01
59.145 ha
MD15-16
147.972 ha
MD10-17
53.549 ha
MD10-16
65.095 ha
CD.NO:53/3
TYPE:BOX
SPAN:1X2 CELL
CH:51000
CH:52000
CH:53500
Gunjuru Palya Kere
Chikka Bellandur Kere
Haldahalli Kere
Katriguppe Kere
Ramarayakanahalli Kere
Chikkanekkundi Kere 2

Figure 5-7: Catchment area details for CD structures C47 to C53

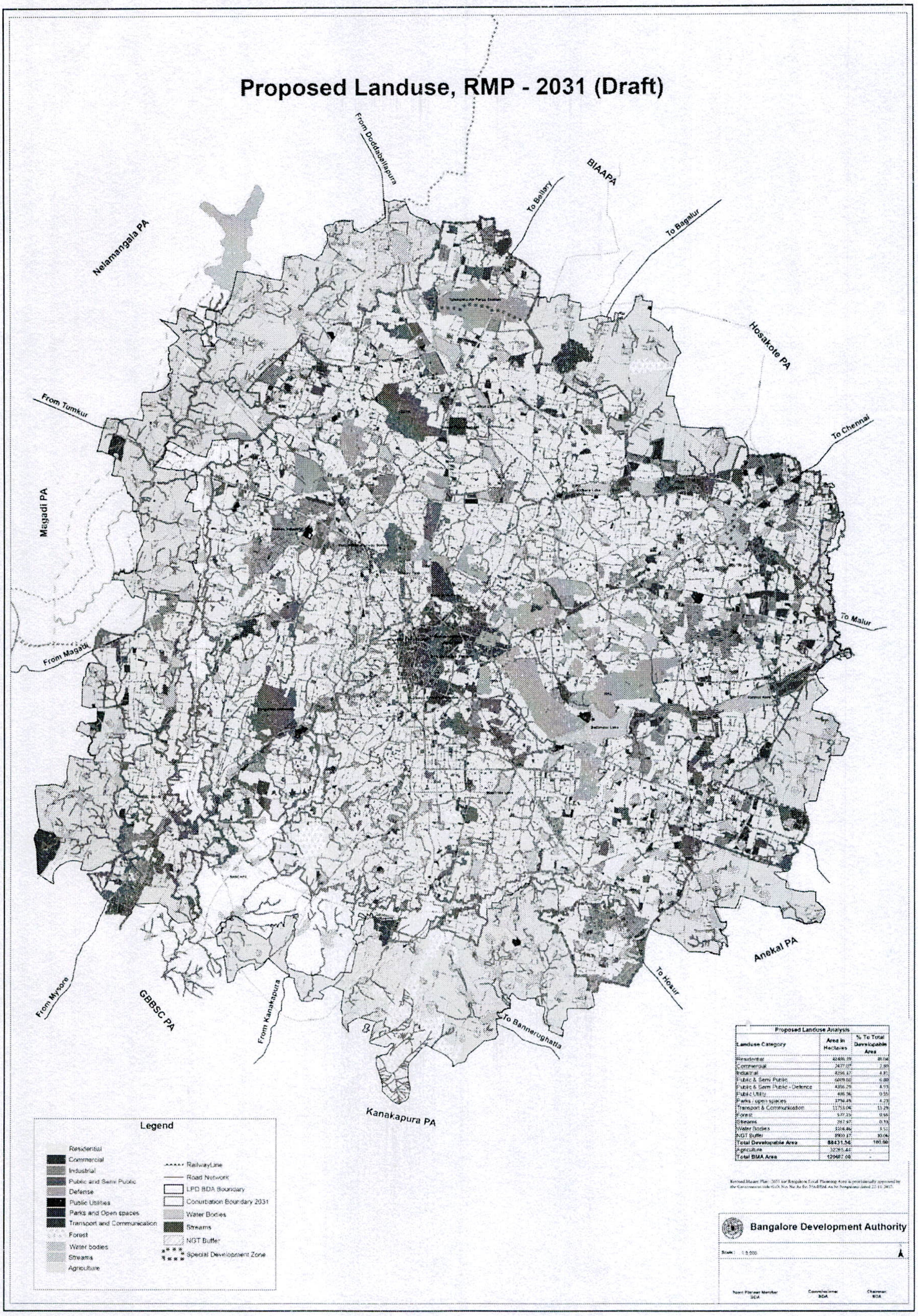
Proposed Landuse, RMP - 2031 (Draft)
From Doddaballapura
BIAAPA
To Bellary
To Bagalur
Nelamangala PA
Hosakote PA
From Tumkur
To Chennai
Magadi PA
To Malur
From Magadi
Anekal PA
From Mysore
GBBSC PA
From Kanakapura
To Hosur
To Bannerughatta
Kanakapura PA
Legend
Residential
Commercial
Industrial
Public and Semi Public
Defense
Public Utilities
Parks and Open spaces
Transport and Communication
Forest
Water bodies
Streams
Agriculture
RailwayLine
Road Network
LPD BDA Boundary
Conurbation Boundary 2031
Water Bodies
Streams
NGT Buffer
Special Development Zone
Proposed Landuse Analysis
Landuse Category
Area in Hectares
% To Total Developable Area
Residential
Commercial
Industrial
Public & Semi Public
Public & Semi Public - Defence
Public Utility
Parks / open spaces
Transport & Communication
Forest
Streams
Water Bodies
NGT Buffer
Total Developable Area 88431.56 100.00
Agriculture
Total BMA Area
Bangalore Development Authority
Scale

Figure 5-8: Proposed Landuse, Revised Master Plan - 2031

5.6 Other Points

- Maximum hourly rainfall , for a 50 year return period is taken as 100mm / 1 hour for Bangalore region.
- Longitudinal slope of box culvert is varied from 1 in 200 to 1 in 1000 (i.e. S=0.005 to 0.001).
- Discharge velocity is assumed as 3 m/sec for all the above calculations.

-----XXXXX-----

SECTION – 6

GRADE SEPARATORS

Column Number			①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
Sl.No.	**CD. Number**	**Chainage (m)**	**Effective Box Width (W) (m)**	**Proposed Box Depth (D) (m)**	**Minimum Vertical Clearance (VC) (m)**	**Effective Depth (d) (m) ②-③**	**Effective Area (A) (m) ①x④**	**Wetted perimeter (P) (m) ①+(2x④)**	**Dischrge Velocity (m/sec) (V)**	**Estimated Discharge to Cater Flood (m3/sec)**	**Design Discharge (m^3/sec) (Q=A x V) ⑤x⑦**	**CD Adequacy Check If ⑨≥⑧ then AD else ID**
C45	48/2	47272	4	2.00	0.45	1.55	6.2	7.1	3	0.48	18.6	AD
C46	49/1	48830	4	2.00	0.60	1.4	5.6	6.8	3	5.17	16.8	AD
C47	50/1	49503	4	2.00	0.60	1.4	5.6	6.8	3	4.39	16.8	AD
C48	50/2	49681	4	2.00	0.45	1.55	6.2	7.1	3	1.22	18.6	AD
C49	50/3	49979	4	2.00	0.60	1.4	5.6	6.8	3	10.87	16.8	AD
C50	51/1	50603	4	2.00	0.45	1.55	6.2	7.1	3	1.54	18.6	AD
C51	51/2	50921	4	2.00	0.45	1.55	6.2	7.1	3	0.61	18.6	AD
C52	52/1	51432	4	2.00	0.15	1.85	7.4	7.7	3	0.26	22.2	AD
C53	53/1	52862	12	2.00	0.90	1.1	13.2	14.2	3	35.37	39.6	AD
C54	56/1	55222	4	2.00	0.45	1.55	6.2	7.1	3	2.22	18.6	AD
C55	57/1	56052	12	2.00	0.9	1.1	13.2	14.2	3	31.32	39.6	AD
C56	58/1	57967	4	2.00	0.6	1.4	5.6	6.8	3	3.32	16.8	AD
C57	59/1	58608	4	2.00	0.45	1.55	6.2	7.1	3	1.29	18.6	AD
C58	59/2	58936	8	2.00	0.6	1.4	11.2	10.8	3	28.67	33.6	AD
C59	60/1	59833	4	2.00	0.6	1.4	5.6	6.8	3	7.20	16.8	AD
C60	62/2	61592	4	2.00	0.6	1.4	5.6	6.8	3	4.08	16.8	AD
C61	63/1	62173	4	2.00	0.45	1.55	6.2	7.1	3	2.86	18.6	AD
C62	64/1	63593	8	2.00	0.6	1.4	11.2	10.8	3	25.75	33.6	AD
C63	65/1	64020	4	2.00	0.6	1.4	5.6	6.8	3	16.20	16.8	AD

*AD =Size of CD is Adequate

Table 5-5: Hydraulic Calculations for CD Structures (adequacy check)

Column Number			①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
Sl.No.	CD. Number	Chainage (m)	Effective Box Width (W) (m)	Proposed Box Depth (D) (m)	Minimum Vertical Clearance (VC) (m)	Effective Depth (d) (m) ②-③	Effective Area (A) (m) ①x④	Wetted perimeter (P) (m) ①+(2x④)	Dischrge Velocity (m/sec) (V)	Estimated Discharge to Cater Flood (m3/sec)	Design Discharge (m^3/sec) (Q=A x V) ⑤x⑦	CD Adequacy Check If ⑨≥⑧ then AD else ID
C1	1/1	525	40	2.00	0.90	1.1	44	42.2	3	124.72	132	AD
C2	3/1	2231	2	2.00	0.60	1.4	2.8	4.8	3	7.37	8.4	AD
C3	3/2	2643	4	2.00	0.60	1.4	5.6	6.8	3	13.86	16.8	AD
C4	5/1	4587	20	2.00	0.90	1.1	22	22.2	3	54.06	66	AD
C5	5/2	4814	6	2.00	0.60	1.4	8.4	8.8	3	18.51	25.2	AD
C6	6/1	5789	4	2.00	0.60	1.4	5.6	6.8	3	10.97	16.8	AD
C7	7/1	6429	2	2.00	0.60	1.4	2.8	4.8	3	6.42	8.4	AD
C8	8/1	7415	2	2.00	0.60	1.4	2.8	4.8	3	3.95	8.4	AD
C9	9/1	8673	2	2.00	0.60	1.4	2.8	4.8	3	3.12	8.4	AD
C10	10/1	9147	2	2.00	0.45	1.55	3.1	5.1	3	1.12	9.3	AD
C11	10/2	9390	3	2.00	0.60	1.4	4.2	5.8	3	2.99	12.6	AD
C12	11/1	10241	2	2.00	0.60	1.4	2.8	4.8	3	6.02	8.4	AD
C13	11/2	10640	2	2.00	0.60	1.4	2.8	4.8	3	4.71	8.4	AD
C14	12/1	11337	2	2.00	0.45	1.55	3.1	5.1	3	2.15	9.3	AD
C15	12/2	11596	2	2.00	0.45	1.55	3.1	5.1	3	1.29	9.3	AD
C16	13/1	12775	3	2.00	0.60	1.4	4.2	5.8	3	10.68	12.6	AD
C17	20/1	19952	6	2.00	0.60	1.4	8.4	8.8	3	21.28	25.2	AD
C18	23/1	22212	12	2.00	0.90	1.1	13.2	14.2	3	33.81	39.6	AD
C19	24/1	23818	3	2.00	0.60	1.4	4.2	5.8	3	5.40	12.6	AD
C20	25/1	24308	2	2.00	0.60	1.4	2.8	4.8	3	5.68	8.4	AD
C21	26/1	25208	4	2.00	0.15	1.85	7.4	7.7	3	0.00	22.2	AD
C22	28/1	27238	4	2.00	0.15	1.85	7.4	7.7	3	0.00	22.2	AD
C23	29/1	28859	4	2.00	0.60	1.4	5.6	6.8	3	16.48	16.8	AD
C24	30/1	29069	8	2.00	0.60	1.4	11.2	10.8	3	25.50	33.6	AD
C25	32/1	31705	4	2.00	0.45	1.55	6.2	7.1	3	2.35	18.6	AD
C26	33/1	32814	4	2.00	0.45	1.55	6.2	7.1	3	1.37	18.6	AD
C27	34/1	33239	4	2.00	0.45	1.55	6.2	7.1	3	0.30	18.6	AD
C28	34/2	33696	15	2.00	0.90	1.1	16.5	17.2	3	42.74	49.5	AD
C29	35/1	34713	4	2.00	0.45	1.55	6.2	7.1	3	2.03	18.6	AD
C30	36/1	35724	6	2.00	0.60	1.4	8.4	8.8	3	19.04	25.2	AD
C31	37/1	36393	4	2.00	0.60	1.4	5.6	6.8	3	4.52	16.8	AD
C32	38/1	37553	4	2.00	0.60	1.4	5.6	6.8	3	13.29	16.8	AD
C33	42/1	41483	4	2.00	0.45	1.55	6.2	7.1	3	1.65	18.6	AD
C34	43/1	42043	12	2.00	0.90	1.1	13.2	14.2	3	30.80	39.6	AD
C35	43/2	42223	4	2.00	0.45	1.55	6.2	7.1	3	1.11	18.6	AD
C36	43/3	42507	4	2.00	0.45	1.55	6.2	7.1	3	2.04	18.6	AD
C37	43/4	42963	4	2.00	0.45	1.55	6.2	7.1	3	1.17	18.6	AD
C38	44/1	43798	12	2.00	0.90	1.1	13.2	14.2	3	34.86	39.6	AD
C39	46/1	45488	4	2.00	0.45	1.55	6.2	7.1	3	2.68	18.6	AD
C40	46/2	45743	4	2.00	0.60	1.4	5.6	6.8	3	6.11	16.8	AD
C41	47/1	46155	12	2.00	0.90	1.1	13.2	14.2	3	31.33	39.6	AD
C42	47/2	46684	4	2.00	0.60	1.4	5.6	6.8	3	3.95	16.8	AD
C43	47/3	46890	4	2.00	0.45	1.55	6.2	7.1	3	0.37	18.6	AD
C44	48/1	47141	4	2.00	0.15	1.85	7.4	7.7	3	0.12	22.2	AD

Sl.No.	CD. Number	Chainage (m)	Catchment Area (Ha)	Runoff coefficient	Calculated Discharge to cater flood frequency (m^3/Sec)	Cross section Required to cater flood frequency (m^2)	Width Proposed (m)	Depth Proposed (m)	Discharge (m^3/Sec)	Type of CD Proposed	Structural Dimension (No of Vent X Span (m))	*Adequacy of CD
C48	50/2	49681	14.69	0.30	1.22	0.41	4	2.00	24	CULVERT	2X2	AD
C49	50/3	49979	123.28	0.32	10.87	3.62	4	2.00	24	CULVERT	2X2	AD
C50	51/1	50603	13.20	0.42	1.54	0.51	4	2.00	24	CULVERT	2X2	AD
C51	51/2	50921	7.32	0.30	0.61	0.20	4	2.00	24	CULVERT	2X2	AD
C52	52/1	51432	3.08	0.30	0.26	0.09	4	2.00	24	CULVERT	2X2	AD
C53	53/1	52862	257.74	0.49	35.37	11.79	12	2.00	72	MINOR BRIDGE	2X6	AD
C54	56/1	55222	13.52	0.59	2.22	0.74	4	2.00	24	CULVERT	2X2	AD
C55	57/1	56052	158.83	0.71	31.32	10.44	12	2.00	72	MINOR BRIDGE	2X6	AD
C56	58/1	57967	39.87	0.30	3.32	1.11	4	2.00	24	CULVERT	2X2	AD
C57	59/1	58608	15.47	0.30	1.29	0.43	4	2.00	24	CULVERT	2X2	AD
C58	59/2	58936	125.63	0.82	28.67	9.56	8	2.00	48	MINOR BRIDGE	2X4	AD
C59	60/1	59833	31.37	0.83	7.20	2.40	4	2.00	24	CULVERT	2X2	AD
C60	62/2	61592	21.76	0.68	4.08	1.36	4	2.00	24	CULVERT	2X2	AD
C61	63/1	62173	15.24	0.68	2.86	0.95	4	2.00	24	CULVERT	2X2	AD
C62	64/1	63593	106.31	0.87	25.75	8.58	8	2.00	48	MINOR BRIDGE	2X4	AD
C63	65/1	64020	68.92	0.85	16.20	5.40	4	2.00	24	CULVERT	2X2	AD

*AD =Size of CD is Adequate

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Table 5-4: Hydrological Calculations of CD Works

Sl.No.	CD. Number	Chainage (m)	Catchment Area (Ha)	Runoff coefficient	Calculated Discharge to cater flood frequency (m^3/Sec)	Cross section Required to cater flood frequency (m^2)	Width Proposed (m)	Depth Proposed (m)	Discharge (m^3/Sec)	Type of CD Proposed	Structural Dimension (No of Vent X Span (m))	*Adequacy of CD
C1	1/1	525	598.64	0.75	124.72	41.57	40	2.00	240	MINOR BRIDGE	4x10	AD
C2	3/1	2231	51.49	0.52	7.37	2.46	2	2.00	12	CULVERT	1X2	AD
C3	3/2	2643	140.18	0.36	13.86	4.62	4	2.00	24	CULVERT	2X2	AD
C4	5/1	4587	341.76	0.57	54.06	18.02	20	2.00	120	MINOR BRIDGE	2X10	AD
C5	5/2	4814	120.04	0.56	18.51	6.17	6	2.00	36	CULVERT	2X3	AD
C6	6/1	5789	48.96	0.81	10.97	3.66	4	2.00	24	CULVERT	2X2	AD
C7	7/1	6429	28.88	0.80	6.42	2.14	2	2.00	12	CULVERT	1X2	AD
C8	8/1	7415	341.76	0.62	3.95	1.32	2	2.00	12	CULVERT	1X2	AD
C9	9/1	8673	3.12	0.80	3.12	1.04	2	2.00	12	CULVERT	1X2	AD
C10	10/1	9147	13.50	0.30	1.12	0.37	2	2.00	12	CULVERT	1X2	AD
C11	10/2	9390	35.88	0.30	2.99	1.00	3	2.00	18	CULVERT	1X3	AD
C12	11/1	10241	63.69	0.34	6.02	2.01	2	2.00	12	CULVERT	1X2	AD
C13	11/2	10640	73.10	0.23	4.71	1.57	2	2.00	12	CULVERT	1X2	AD
C14	12/1	11337	16.93	0.46	2.15	0.72	2	2.00	12	CULVERT	1X2	AD
C15	12/2	11596	12.43	0.37	1.29	0.43	2	2.00	12	CULVERT	1X2	AD
C16	13/1	12775	60.55	0.64	10.68	3.56	3	2.00	18	CULVERT	1X3	AD
C17	20/1	19952	95.07	0.81	21.28	7.09	6	2.00	36	CULVERT	2X3	AD
C18	23/1	22212	152.82	0.80	33.81	11.27	12	2.00	72	MINOR BRIDGE	2X6	AD
C19	24/1	23818	27.76	0.70	5.40	1.80	3	2.00	18	CULVERT	1X3	AD
C20	25/1	24308	27.64	0.74	5.68	1.89	2	2.00	12	CULVERT	1X2	AD
C21	26/1	25208	0.00	0.00	0.00	0.00	4	2.00	24	CULVERT	2X2	AD
C22	28/1	27238	0.00	0.00	0.00	0.00	4	2.00	24	CULVERT	2X2	AD
C23	29/1	28859	74.15	0.80	16.48	5.49	4	2.00	24	CULVERT	2X2	AD
C24	30/1	29069	158.30	0.58	25.50	8.50	8	2.00	48	MINOR BRIDGE	2X4	AD
C25	32/1	31705	13.07	0.65	2.35	0.78	4	2.00	24	CULVERT	2X2	AD
C26	33/1	32814	16.44	0.30	1.37	0.46	4	2.00	24	CULVERT	2X2	AD
C27	34/1	33239	3.65	0.30	0.30	0.10	4	2.00	24	CULVERT	2X2	AD
C28	34/2	33696	437.15	0.35	42.74	14.25	15	2.00	90	MINOR BRIDGE	3X5	AD
C29	35/1	34713	12.16	0.60	2.03	0.68	4	2.00	24	CULVERT	2X2	AD
C30	36/1	35724	104.50	0.66	19.04	6.35	6	2.00	36	CULVERT	2X3	AD
C31	37/1	36393	20.79	0.78	4.52	1.51	4	2.00	24	CULVERT	2X2	AD
C32	38/1	37553	59.80	0.80	13.29	4.43	4	2.00	24	CULVERT	2X2	AD
C33	42/1	41483	12.53	0.48	1.65	0.55	4	2.00	24	CULVERT	2X2	AD
C34	43/1	42043	165.84	0.67	30.80	10.27	12	2.00	72	MINOR BRIDGE	2X6	AD
C35	43/2	42223	13.26	0.30	1.11	0.37	4	2.00	24	CULVERT	2X2	AD
C36	43/3	42507	9.20	0.80	2.04	0.68	4	2.00	24	CULVERT	2X2	AD
C37	43/4	42963	14.00	0.30	1.17	0.39	4	2.00	24	CULVERT	2X2	AD
C38	44/1	43798	170.06	0.74	34.86	11.62	12	2.00	72	MINOR BRIDGE	2X6	AD
C39	46/1	45488	12.08	0.80	2.68	0.89	4	2.00	24	CULVERT	2X2	AD
C40	46/2	45743	27.47	0.80	6.11	2.04	4	2.00	24	CULVERT	2X2	AD
C41	47/1	46155	148.82	0.76	31.33	10.44	12	2.00	72	MINOR BRIDGE	2X6	AD
C42	47/2	46684	71.02	0.20	3.95	1.32	4	2.00	24	CULVERT	2X2	AD
C43	47/3	46890	3.17	0.42	0.37	0.12	4	2.00	24	CULVERT	2X2	AD
C44	48/1	47141	2.10	0.20	0.12	0.04	4	2.00	24	CULVERT	2X2	AD
C45	48/2	47272	2.95	0.59	0.48	0.16	4	2.00	24	CULVERT	2X2	AD
C46	49/1	48830	54.94	0.34	5.17	1.72	4	2.00	24	CULVERT	2X2	AD
C47	50/1	49503	45.75	0.35	4.39	1.46	4	2.00	24	CULVERT	2X2	AD

Sl No		Design Chainage,m	Location
11	Whitefield road grade separator	38986.000	Entry and Exit plaza – left side of interchange
12		40958.000	Entry and Exit plaza – right side of interchange
13	Channasandra road grade separator	43295.000	Entry and Exit plaza – left side of interchange
14		44418.000	Entry and Exit plaza – right side of interchange
15	B'lore Sarjapura road grade separator	54632.000	Entry and Exit plaza – left side of interchange
16		56368.000	Entry and Exit plaza – right side of interchange
17	Hosur road interchange	63075.000	Main road toll plaza

Design Elements for Toll Plaza is given in following sections.

7.4.1 Layout

Two types of toll plaza layouts are proposed for PRR. They are:

- Toll Plaza on main road at start and end of the project road integrated with NICE road (ref Figure 7-1).
- Toll Plaza at entry and exit of interchanges. These are provided at 8 intermittent junctions to capture traffic from side roads (ref Figure 7-2).

Adequate numbers of toll lanes are proposed at each toll plaza. The number of toll lanes will be two for regular traffic and one for oversized vehicles to start with, but the layout has adequate provision for expansion to cater for future traffic.

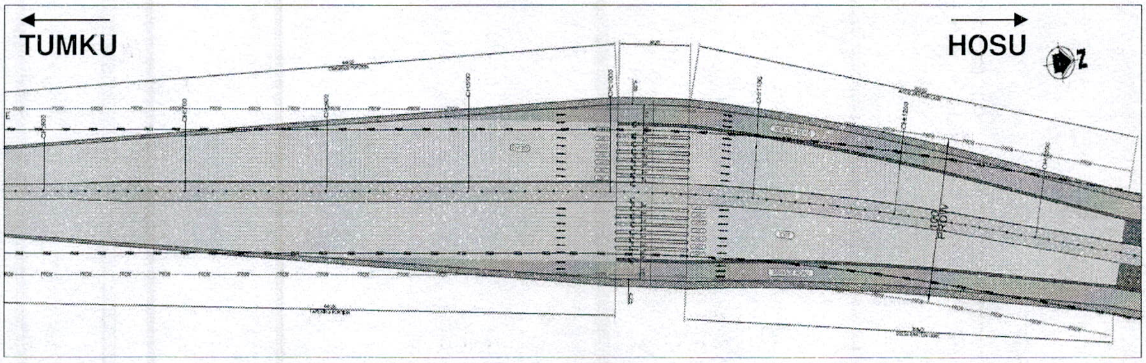


Figure 7-1: Main Toll Plaza at Tumkur Road

facilities like toilets, dormitory, rest rooms, medical shops, dispensary, ATMs. In addition, rest area will also comprise of sufficient working area and space for repair shops, vulcanizing shops, service centre, spare parts shops, telephone booth, hotels and light refreshments with first aid facilities can be provided. Rest area will be adequately lit with high mast lighting. The whole area will be elaborately landscaped to provide a pleasing environment.

7.4 Toll Plaza

The main road of PRR will be a tollable road. The project road starts at NH-4 on Tumkur road and ends at NH-7 on Hosur road integrating with existing NICE road thereby completing "full circle" of road network. There are 10 major intersection points along PRR. BDA is desirous of collecting toll for main road users. Details of proposed Toll Plazas at all 10 locations are mentioned below in Table 7-2.

Typically, two types of toll plazas are proposed:

- Toll Plaza on main road at Tumkur and Hosur end to capture and toll traffic coming to / from NICE road.
- Toll Plaza at entry and exit to main road from side roads at all major junctions.

Table 7-2: Locations of Toll Plazas

Sl No		Design Chainage,m	Location
1	Tumkur road interchange	1030.000	Main road toll plaza
2	Hessarghatta ROB / Grade Separator	5500.000	Entry and Exit plaza – right side of interchange
3	Doddaballapur road grade separator	13365.000	Entry and Exit plaza – left side of interchange
4		15616.000	Entry and Exit plaza – right side of interchange
5	Bellary road grade separator	17840.000	Entry and Exit plaza – left side of interchange
6		19540.000	Entry and Exit plaza – right side of interchange
7	Hennur road grade separator	24600.000	Entry and Exit plaza – left side of interchange
8		26434.000	Entry and Exit plaza – right side of interchange
9	Old Madras road grade separator	35085.000	Entry and Exit plaza – left side of interchange
10		36934.000	Entry and Exit plaza – right side of interchange

32	33.470	LHS	Herandahalli
33	33.770	RHS	Herandahalli
34	36.100	LHS &RHS	Chimsandra
35	37.900	LHS &RHS	Doddabanahalli
36	38.500	LHS &RHS	Kannamanagala
37	40.000	LHS &RHS	Sigehalli
38	41.500	LHS &RHS	Sigehalli
39	44.000	LHS &RHS	Channasandra
40	45.300	LHS &RHS	Nagagondanahalli
41	46.450	LHS &RHS	Hagadur
42	47.400	LHS	Sorahunse
43	47.750	RHS	Sorahunse
44	48.800	LHS &RHS	Sorahunse
45	50.000	LHS &RHS	Varthur
46	51.100	LHS &RHS	Gunjur
47	52.500	LHS &RHS	Kachamaranahalli
48	53.500	LHS &RHS	Kachamaranahalli
49	55.550	LHS &RHS	Sulakunte
50	57.200	LHS &RHS	Kodathi / Chokkasandra
51	59.000	LHS &RHS	Gattihalli
52	60.700	LHS &RHS	Chikkanagamangala
53	61.800	LHS &RHS	Doddanagamangala
54	62.750	LHS &RHS	Doddanagamangala

7.3.2 Rest Areas

Rest areas are proposed at 3 locations, one each in each sections. These are proposed to be located near to Interchanges / toll plazas. The exact location of rest area will be dependent on land acquisition extents proposed by BDA. Typically, rest area will include

4	4.800	LHS &RHS	Chikkabanavara
5	6.900	LHS &RHS	Kalathammanahalli
6	7.750	LHS &RHS	Byalakere
7	8.700	LHS	Byalakere
8	9.050	RHS	Byalakere
9	10.500	LHS	Mavallipura
10	10.900	RHS	Mavallipura
11	11.550	LHS &RHS	JarakabandeKavalu
12	12.400	LHS	JarakabandeKavalu
13	12.750	RHS	Ramagondanahalli
14	14.600	LHS &RHS	NagareswaraNagenahalli
15	16.300	LHS &RHS	Vasudevapura
16	17.300	LHS &RHS	Manchenahalli
17	18.500	LHS	Venkatala
19	18.850	RHS	Venkatala
20	20.000	LHS &RHS	Kogilu
21	21.050	LHS	Kogilu
22	21.350	RHS	Agrahara
23	23.250	LHS	Chokkanahalli
24	23.550	RHS	Chokkanahalli
25	25.450	LHS	Byrathi
26	25.800	RHS	Byrathi
27	27.100	LHS &RHS	Doddagubbi
28	28.250	LHS &RHS	Bileshivali
29	29.920	LHS &RHS	Vaderahalli
30	31.350	LHS	Aduru
31	31.650	RHS	Aduru

800mm. They are proposed at approaches to bridge structures and median of toll plaza islands.

7.2.6 Kilometer Stone

The details of kilometer stones are in accordance with IRC: 8-1980 guidelines. Kilometer stones are located on the left-hand side of the road as one proceeds from the station from which the Kilometer count starts. Kilometer stones shall be fixed at right angles to the centre line of the carriageway.

The details of 200m stones and boundary stones conform to IRC: 26-1967 and IRC: 25-1967. 200m stones are located on the same side of the road as the kilometer stones. The inscription on the stones shall be the numerals 2, 4, 6 and 8 marked in an ascending order in the direction of increasing kilometer away from the starting station. The numerals shall be 80mm high. The colour of the numerals shall be black on a white background. Boundary stones shall be located on either side of the road opposite every 200m stone and kilometre stone. In addition these shall be fixed at all angular points of the boundary. Where the boundary is on a curve or the land is of significant value and likely to be encroached upon, the boundary stones, as required, shall be installed at closer intervals.

7.3 Way Side Amenities

Various amenities proposed for the project include bus shelters, rest areas and toll plazas. These are explained in following section.

7.3.1 Bus Shelters

Exclusive bus bays are not provided on the project road. BMTC buses are expected to move on service road. Since the project road has to be confined within 75m ROW, exclusive bus bays as per IRC cannot be provided. Hence, only bus shelters are proposed. Bus shelters are proposed without taper. A raised footpath of 2.0 m wide is proposed along with shelter for the safety of waiting passengers. The locations of proposed Bus shelter are presented in Table 7-1.

Table 7-1: Location of Bus Shelters

Sl No	Design Chainage,Km	Side	Location
1	1.450	LHS &RHS	Totadaguddahalli
2	2.450	LHS &RHS	Tammenahalli
3	3.700	LHS &RHS	Soladevanahalli

Centre, edge line, stop line, give way line, diagonal/chevron markings, parking etc shall be painted with hot applied thermoplastic paints with reflect rising glass beads as per MOSRTH specification. At toll plaza, transverse bar lines with width of 300 mm and spacing 15-20 m @ c\c shall be provided across the flare approach to toll plaza to reduce speed of vehicles.

7.2.3 Road Delineators

Roadway indicators are intended to mark the edges of the roadway so as to guide drivers on the alignment ahead. Hazard markers used to define obstructions like guardrails and abutment adjacent to carriageway and bridges which are narrower than the normal width.

Object markers are used to indicate hazards and obstructions within the vehicle flow path, for example, channeling islands close to the intersections.

Delineators and object markers are provided in accordance with the provisions of IRC:79. They are basically driving aids and should not be regarded as substitutes for warning signs, road markings or barriers.

7.2.4 Metal Crash Barrier

Metal Beam Crash Barrier is proposed all along the stretch at superelevated sections, sides of drain separating main road and service road. Thire Metal beam rail shall be of W-profile corrugated sheet steel beams comply with the following mechanical properties.

- Tensile strength, Min = 483 MPA
- Elongation in 2 inches, Min = 12%
- Yield, Min = 345 MPA

The beam elements shall have nominal width of 483mm. Post consists of formed channel of size 150 x 75 x 5, 785mm long and space consists of formed channel of size 150 x 75 x 5, 330 mm long. All members of the system should be hot dipped galvanized to have a minimum counting of 550g/sqm, each face in compliance to relevant MOSRT&H Specification (Cl. 810). The spacing of posts should be 2.0m c/c. Crash barrier system absorbs impact of vehicle and laterally restrains a vehicle from veering off. This ensures minimum damage to the vehicle and passengers.

7.2.5 Concrete Crash Barrier

New jersey concrete barriers are rigid barriers having specifically designed to minimize damage and reduce the likelihood of a car crossing into oncoming lanes in the event of a collision. The barrier will be of pre-cast in M 30 concrete grade preferably having height of

7 TRAFFIC SAFETY AND APPURTENANCES

7.1 General

The proposed PRR will be in urban section for most of the length. The main road will be an access controlled road for fast moving traffic while service road will cater for slow moving and pedestrian traffic. While it is necessary to plan and design the roadway features of the road like geometry, pavement and structures, it is equally important to ensure that the road so designed has adequate safety devises and appurtenances.

Traffic control devices/Road safety devices/Road side furniture will comprise of road signs, road markings, objects / hazard markers, road studs, roadway delineators, attenuators, safety barriers, pedestrian guard rails, metal crash barriers, boundary stones, kilometer stones, etc.

7.2 Road Furniture

Various types of road furniture proposed for the project are given in following sections.

7.2.1 Road Signs

The three type of road signs viz Cautionary, Mandatory and Informatory signs have been provided depending on the situation and function they perform in accordance with the IRC: 67-2012 and Section 802 of MORTH guidelines . Kerb mounted sign shall be supported on GI pipe and overhead sign shall be structurally supported gantry or cantilever. Road sign on main road will be with inserts from drain top / at side of central median, while road sign installation on service road will be on footpath edge.

All road signs shall be of prismatic grade sheeting corresponding to Class C sheeting and any types of IX or X as per ASTM standards.

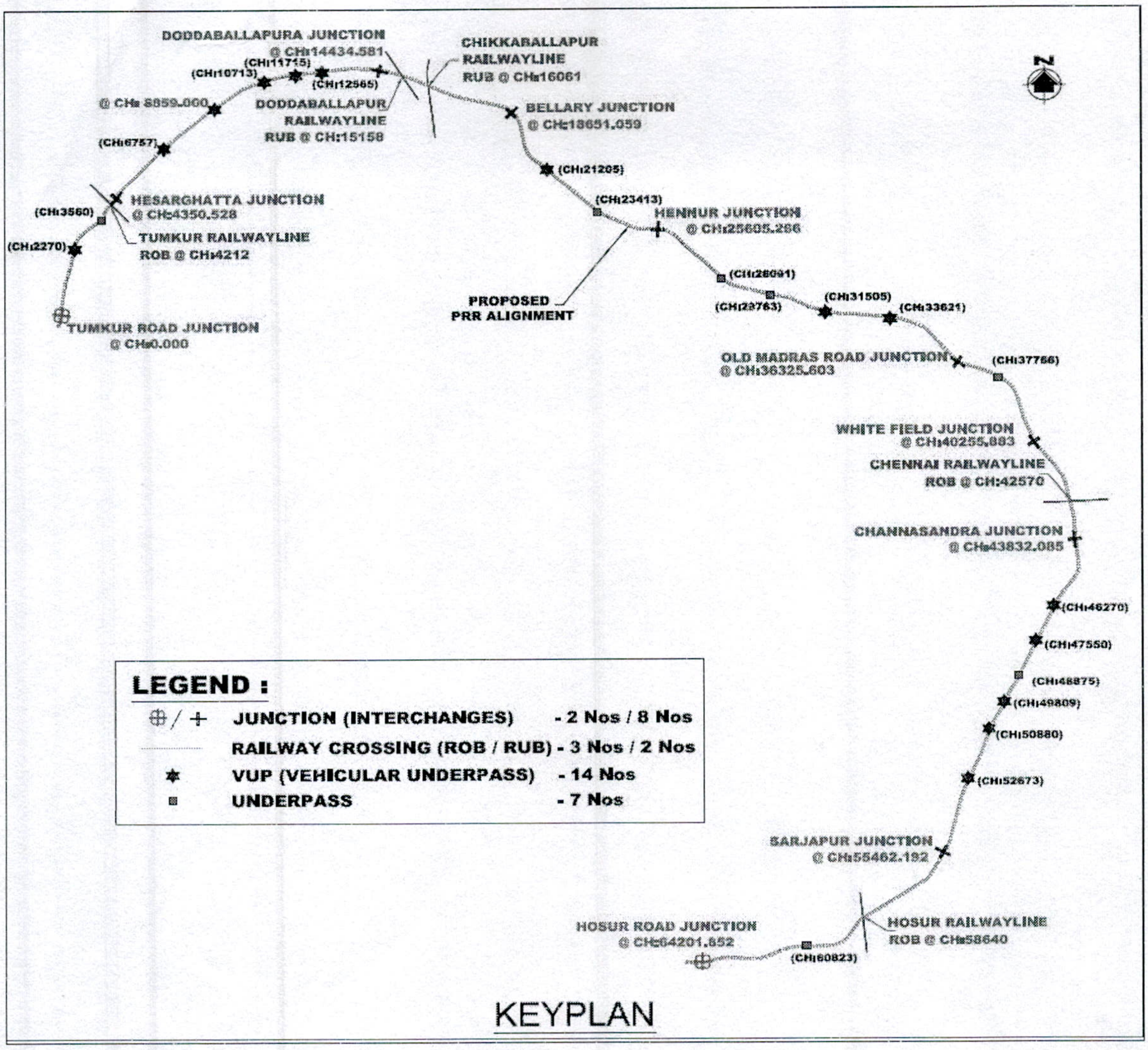
7.2.2 Road Markings

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The Code of Practice for Road Markings, IRC: 35- 1997, has been used in the study as the design basis.

The location and type of marking lines, material and color is followed using IRC: 35-1997 "Code of Practice for Road Markings".

SECTION – 7

TRAFFIC SAFETY AND APPURTENANCES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BELLARY JUNCTION
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(CH:21205)
HESARGHATTA JUNCTION
@ CH:4350.528
(CH:3560)
TUMKUR RAILWAYLINE ROB @ CH:4212
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(CH:23413)
HENNUR JUNCTION
@ CH:25605.266
(CH:28091)
(CH:29763)
(CH:31505)
(CH:33621)
PROPOSED PRR ALIGNMENT
TUMKUR ROAD JUNCTION
@ CH:0.000
OLD MADRAS ROAD JUNCTION
@ CH:36325.603
(CH:37766)
WHITE FIELD JUNCTION
@ CH:40255.883
CHENNAI RAILWAYLINE ROB @ CH:42570
CHANNASANDRA JUNCTION
@ CH:43832.085
(CH:46270)
(CH:47550)
(CH:48875)
(CH:49809)
(CH:50880)
(CH:52673)
SARJAPUR JUNCTION
@ CH:55462.192
HOSUR ROAD JUNCTION
@ CH:64201.852
HOSUR RAILWAYLINE ROB @ CH:58640
(CH:60823)
N
LEGEND :
⊕ / + JUNCTION (INTERCHANGES) - 2 Nos / 8 Nos
RAILWAY CROSSING (ROB / RUB) - 3 Nos / 2 Nos
✱ VUP (VEHICULAR UNDERPASS) - 14 Nos
▪ UNDERPASS - 7 Nos
KEYPLAN

Figure 6-2: Key Plan showing locations of Interchanges, VUP, ROB/RUB

Following are the list of flyovers / grade separators proposed for the project.

Table 6-1: List of proposed grade separators

Sl. No.	Chainage, Km	Intersecting Road Name	Suggested Proposal
1.	0.000	Tumkur Road (NH-4)	Cloverleaf interchange integrated with NICE road
2.	4+350.528	Hesarghatta Road	Flyover along PRR
3.	14+434.581	Doddaballapur	Vehicular underpass along PRR
4.	18+651.059	Bellary Road (NH-7)	Vehicular underpass along PRR
5.	25+605.266	Hennur Road	Vehicular underpass along PRR
6.	36+325.603	Old Madras Road (NH-4)	Flyover along PRR

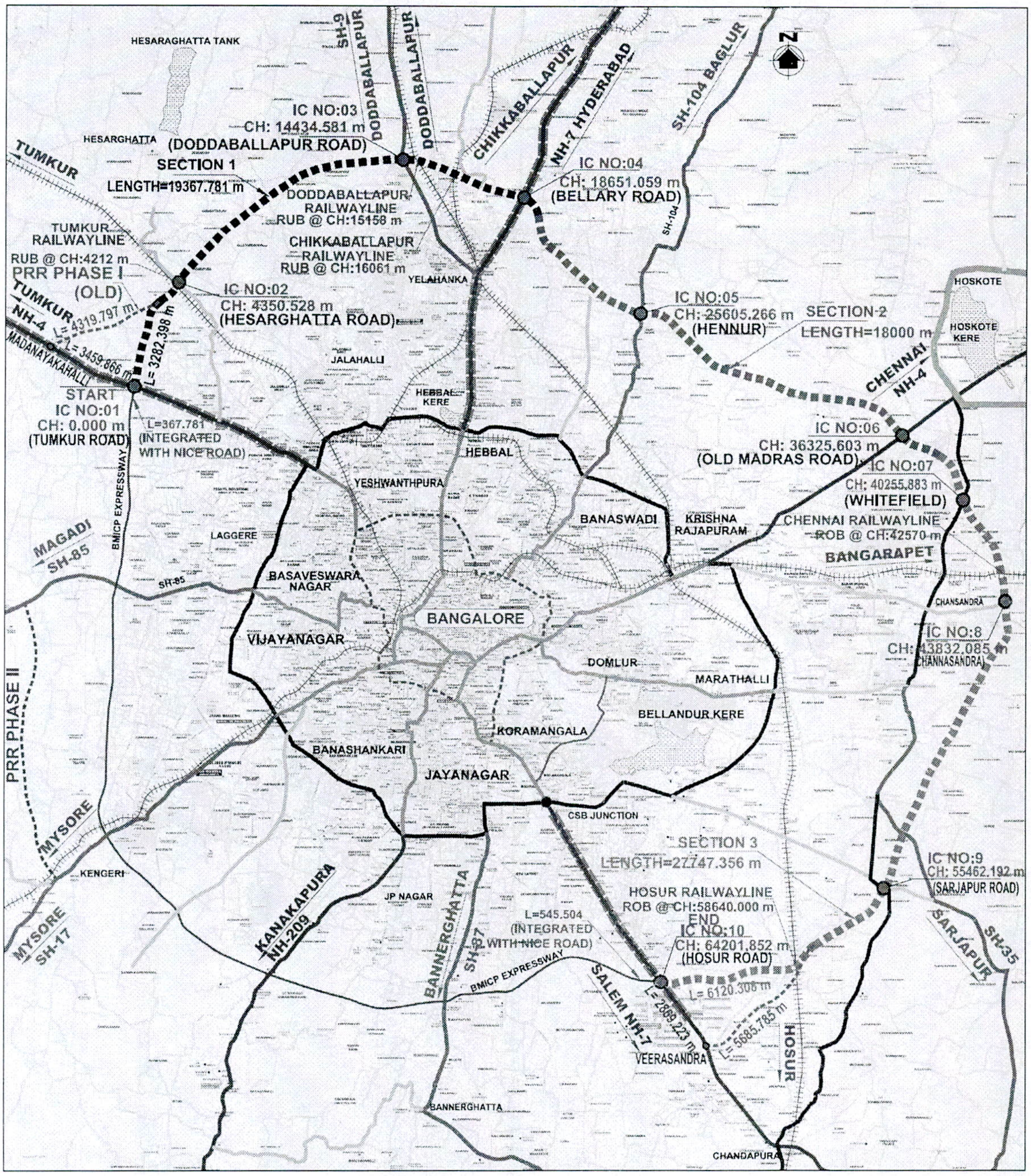

HESARAGHATTA TANK
HESARGHATTA
SH-9
DODDABALLAPUR
DODDABALLAPUR
CHIKKABALLAPUR
NH-7 HYDERABAD
SH-104 BAGLUR
N
IC NO:03
CH: 14434.581 m
(DODDABALLAPUR ROAD)
SECTION 1
LENGTH=19367.781 m
TUMKUR
DODDABALLAPUR RAILWAYLINE RUB @ CH:15158 m
CHIKKABALLAPUR RAILWAYLINE RUB @ CH:16061 m
IC NO:04
CH: 18651.059 m
(BELLARY ROAD)
SH-104
TUMKUR RAILWAYLINE
RUB @ CH:4212 m
PRR PHASE I
(OLD)
TUMKUR
NH-4
MADANAYAKAHALLI
L=4319.797 m
L=3459.866 m
L= 3282.398 m
IC NO:02
CH: 4350.528 m
(HESARGHATTA ROAD)
YELAHANKA
JALAHALLI
HEBBAL KERE
IC NO:05
CH: 25605.266 m
(HENNUR)
SECTION 2
LENGTH=18000 m
HOSKOTE
HOSKOTE KERE
CHENNAI NH-4
START
IC NO:01
CH: 0.000 m
(TUMKUR ROAD)
L=367.781
(INTEGRATED WITH NICE ROAD)
HEBBAL
YESHWANTHPURA
IC NO:06
CH: 36325.603 m
(OLD MADRAS ROAD)
IC NO:07
CH: 40255.883 m
(WHITEFIELD)
CHENNAI RAILWAYLINE ROB @ CH:42570 m
BANGARAPET
BANASWADI
KRISHNA RAJAPURAM
BMICP EXPRESSWAY
LAGGERE
MAGADI SH-85
SH-85
BASAVESWARA NAGAR
BANGALORE
CHANSANDRA
IC NO:8
CH: 43832.085 m
(CHANNASANDRA)
VIJAYANAGAR
DOMLUR
MARATHALLI
BELLANDUR KERE
PRR PHASE II
KORAMANGALA
BANASHANKARI
JAYANAGAR
CSB JUNCTION
SECTION 3
LENGTH=27747.356 m
IC NO:9
CH: 55462.192 m
(SARJAPUR ROAD)
MYSORE
KENGERI
HOSUR RAILWAYLINE ROB @ CH:58640.000 m
END
IC NO:10
CH: 64201.852 m
(HOSUR ROAD)
MYSORE SH-17
KANAKAPURA NH-209
JP NAGAR
BANNERGHATTA
SH-87
L=545.504
(INTEGRATED WITH NICE ROAD)
BMICP EXPRESSWAY
SALEM NH-7
L= 2869.223 m
L= 6120.306 m
L= 5685.785 m
VEERASANDRA
HOSUR
SARJAPUR
SH-35
BANNERGHATTA
CHANDAPURA

Figure 6-1: Key Plan showing locations of Intersections

6 GRADE SEPARATORS

6.1 Introduction

The project road crosses major junctions at 10 locations and railway crossings at 5 locations. Key Plan showing major junction and railway crossings are given in Figure 6-1 and details of proposal for major intersections is given in Table 6-1 and railway crossings in Table 6-2.

As the project road is fully access control, underpasses are proposed for cross road traffic to cross the PRR without obstructing the main stream traffic. Key Plan showing location of facilities proposed is given in Table 6-3.

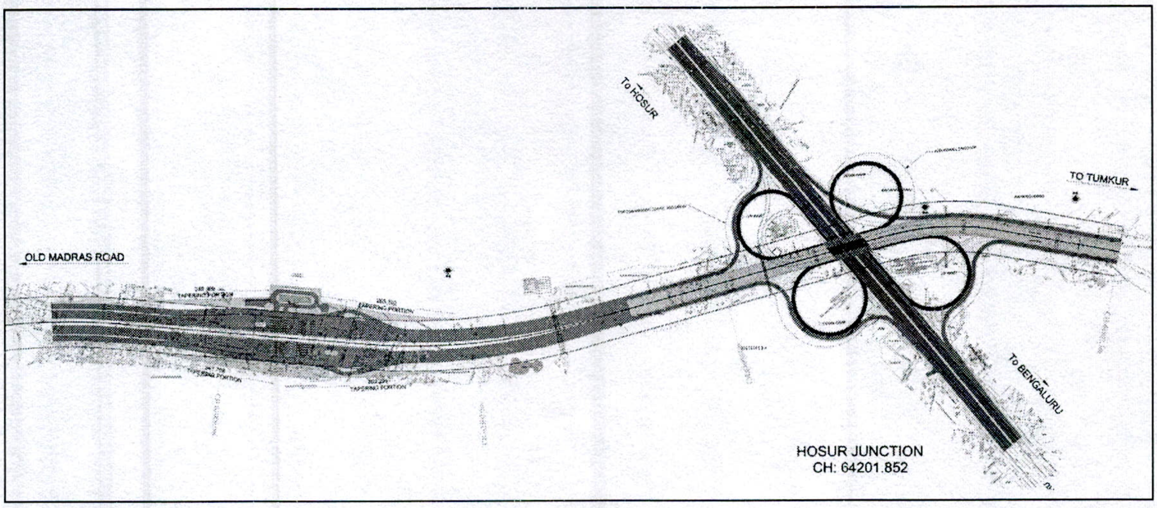

OLD MADRAS ROAD
TAPERING PORTION
TAPERING PORTION
TAPERING PORTION
TAPERING PORTION
To HOSUR
TO TUMKUR
To BENGALURU
HOSUR JUNCTION
CH: 64201.852

Figure 6-12: Proposed Cloverleaf Interchange at Hosur Road

-----XXXXX-----

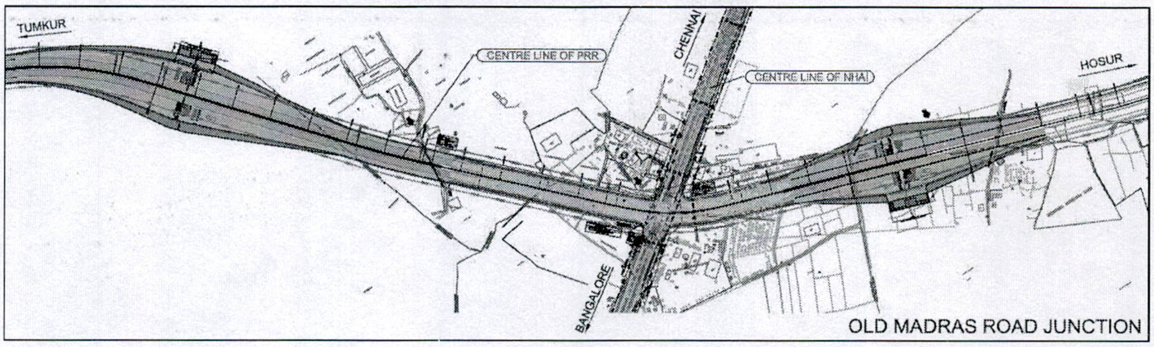

TUMKUR
CENTRE LINE OF PRR
CHENNAI
CENTRE LINE OF NHAI
HOSUR
BANGALORE
OLD MADRAS ROAD JUNCTION

Figure 6-8: Revised Grade Separator Option at Old Madras Road Junction

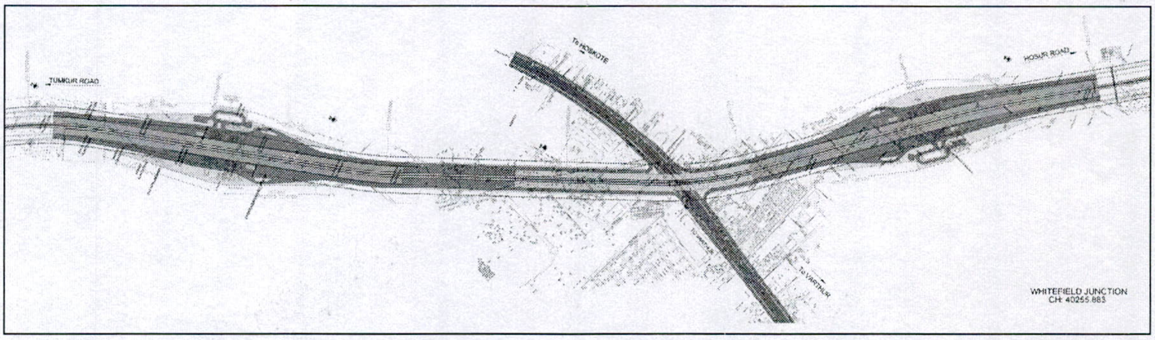

TUMKUR ROAD
To HOSKOTE
HOSUR ROAD
To VARTHUR
WHITEFIELD JUNCTION
CH: 40255.883

Figure 6-9: Proposed Flyover at Whitefield Junction

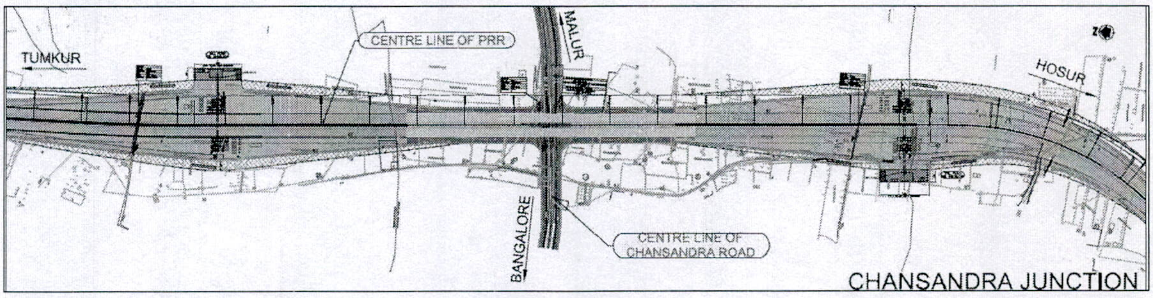

TUMKUR
CENTRE LINE OF PRR
MALUR
HOSUR
BANGALORE
CENTRE LINE OF CHANSANDRA ROAD
CHANSANDRA JUNCTION

Figure 6-10: Proposed Grade Separator at Channasandra Junction

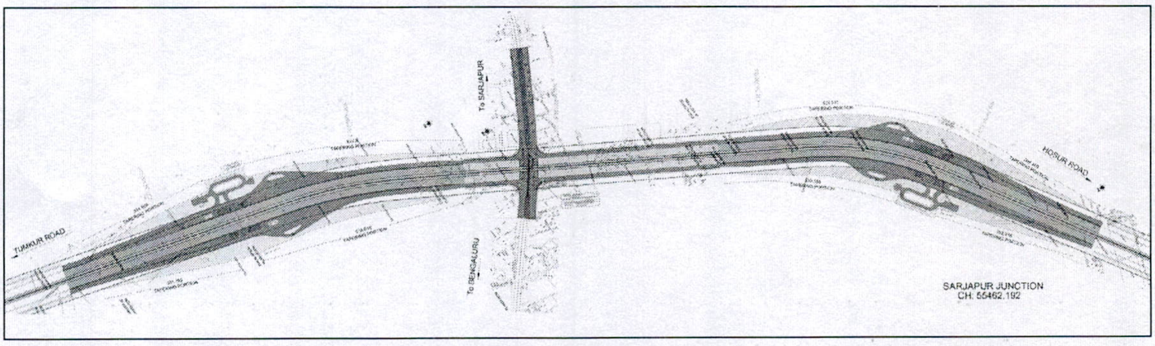

To SARJAPUR
TUMKUR ROAD
HOSUR ROAD
To BENGALURU
SARJAPUR JUNCTION
CH: 55462.192

Figure 6-11: Proposed Underpass at Sarjapura Junction

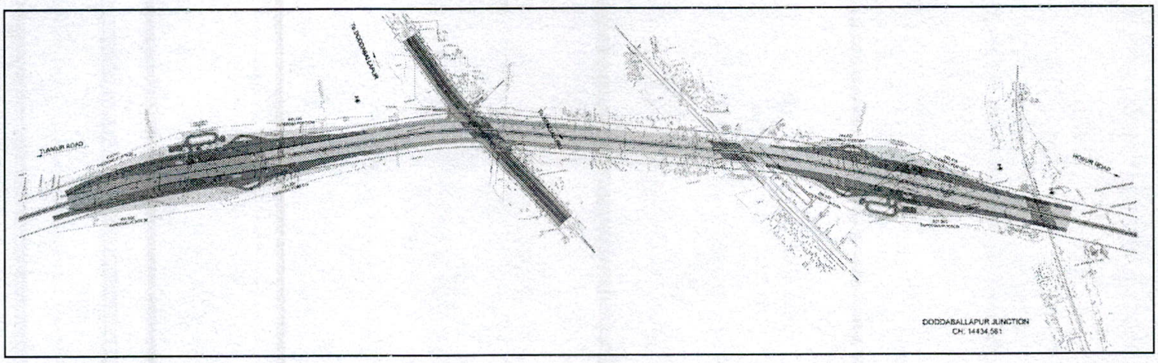

TUMKUR ROAD
HOSUR ROAD
DODDABALLAPUR JUNCTION
CH: 14434.581

Figure 6-5: Proposed Underpass at Doddaballapur Junction

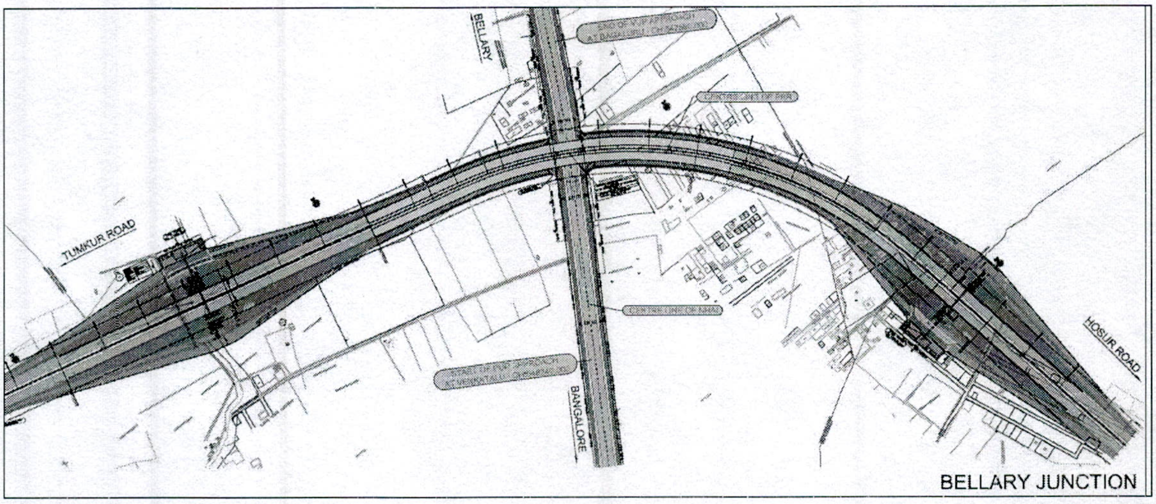

BELLARY
TUMKUR ROAD
HOSUR ROAD
BANGALORE
BELLARY JUNCTION

Figure 6-6: Revised Grade Separator Option at Bellary Junction

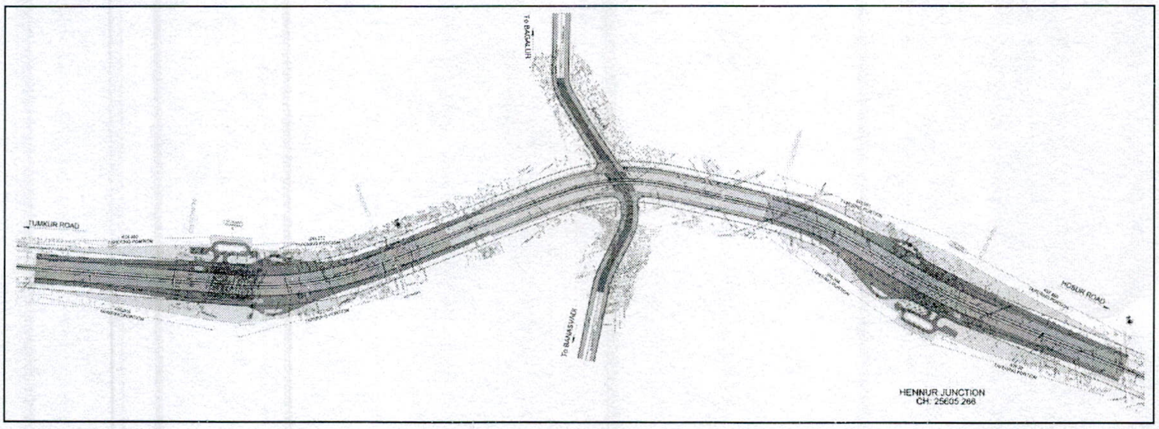

To BAGALUR
TUMKUR ROAD
To BANASWADI
HOSUR ROAD
HENNUR JUNCTION
CH: 25605.268

Figure 6-7: Proposed Underpass at Hennur Junction

prepared and presented to Technical Advisory Committee on 16/01/2029 and 05/02/2019. Part plan of grade separators at all 10 junctions with toll plazas on either side is given from Figure 6-3 to Figure 6-12.

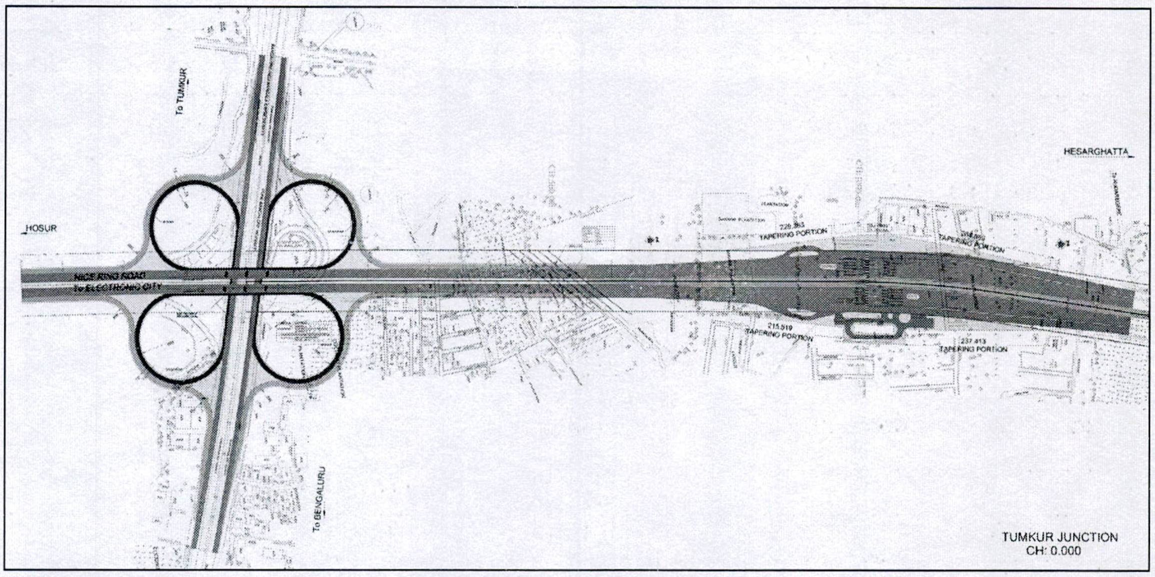

To TUMKUR
HESARGHATTA
HOSUR
NICE RING ROAD
To ELECTRONIC CITY
229.363
TAPERING PORTION
TAPERING PORTION
215.519
TAPERING PORTION
237.413
TAPERING PORTION
To BENGALURU
TUMKUR JUNCTION
CH: 0.000

Figure 6-3: Proposed Cloverleaf interchange at Tumkur Road

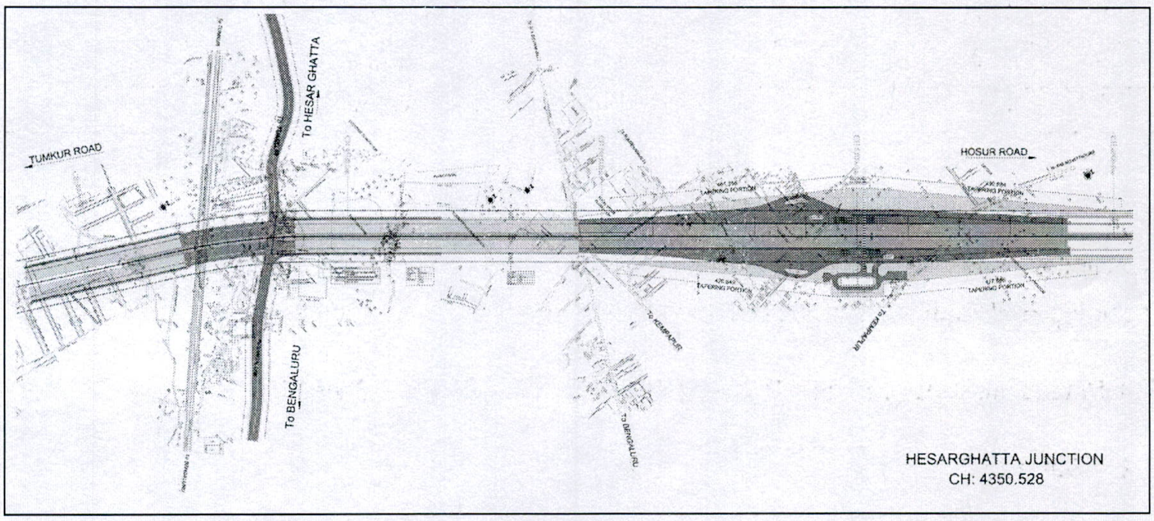

To HESAR GHATTA
TUMKUR ROAD
HOSUR ROAD
TAPERING PORTION
TAPERING PORTION
TAPERING PORTION
TAPERING PORTION
To KEMPAPUR
To KEMPAPUR
To BENGALURU
To BENGALURU
HESARGHATTA JUNCTION
CH: 4350.528

Figure 6-4: Proposed Flyover at Hessaraghatta Junction

SL No	Design Chainage		Length (m)	Type of Cross Section	Remarks		
	From	To			Structure Type	Chainage (m)	Radius of curvature (m)
10	46225.000	46315.000	90.000	5	VUP	46270.000	Straight
11	47505.000	47595.000	90.000	5	VUP	47550.000	Straight
12	49764.000	49854.000	90.000	5	VUP	49809.000	1000
13	50835.000	50925.000	90.000	5	VUP	50880.000	2600
14	52628.000	52718.000	90.000	5	VUP	52673.000	Straight

Table 6-4: List of Proposed Vehicular Overpass

Sl No	Design Chainage, Km	Location
1	3.560	Chikkabanavara to Soladevanahalli
2	23.413	Nagavara to Byalahalli
3	28.091	Bileshivale to Doddagubbi
4	29.763	Rampura to Anagalapura
5	37.766	Doddabanahalli to Kannamangala
6	48.875	Chikka Tirupathi to Mutsandra
7	60.823	Silicon Town to Rayasandra

Note : It may be noted that locations of underpasses and overpasses may undergo change w.r.t location and site requirements during construction. Generally all existing cross roads including RMP roads are proposed to be connected to service roads of PRR.

Toll Plazas are proposed on either side of grade separators at 10 junctions.

6.2 References

Designs of interchanges are carried out in accordance following IRC codes:

- IRC: SP: 90-2012- Manual for Grade separators and elevated structures.
- IRC: 92-1985 – Guidelines for the design of interchanges for the urban area.

6.3 Changes from Earlier DPR

The earlier version of the Detailed Project Report was prepared considering 13 grade separators. BDA has asked the consultant to simplify clover leaf interchange facility at Bellary Road and Old Madras Road considering the land acquisition. Layout plans are

Sl. No.	Chainage, Km	Intersecting Road Name	Suggested Proposal
7.	40+255.883	Whitefield-Hoskote Road	Flyover along PRR
8.	43+832.085	Channasandra Road	Flyover along PRR
9.	55+462.192	Sarjapur Road	Vehicular underpass along PRR
10.	64+201.852	Hosur Road (NH-7)	Cloverleaf interchange integrated with NICE road

Table 6-2: List of proposed ROB / RUB

Sl. No.	Chainage, Km	Intersecting Railway crossing	Type of Proposal
1.	4+212	Tumkur railway line	Road over bridge(ROB)
2.	15+158	Doddaballapur railway line	Road under bridge(RUB)
3.	16+061	Chikkaballapura railway line	Road under bridge(RUB)
4.	42+570	Chennai railway line	Road over bridge(ROB)
5.	58+640	Salem railway line	Road over bridge(ROB)

Table 6-3: List of proposed Vehicular Underpass

SL No	Design Chainage		Length (m)	Type of Cross Section	Remarks		
	From	To			Structure Type	Chainage (m)	Radius of curvature (m)
Package - I							
1	2225.000	2315.000	90.000	5	VUP	2270.000	Straight
2	6712.000	6802.000	90.000	5	VUP	6757.000	Straight
3	8814.000	8904.000	90.000	5	VUP	8859.000	Straight
4	10668.000	10758.000	90.000	5	VUP	10713.000	1750
5	11670.000	11760.000	90.000	5	VUP	11715.000	Straight
6	12520.000	12610.000	90.000	5	VUP	12565.000	Straight
Package - II							
7	21160.000	21250.000	90.000	5	VUP	21205.000	800
8	31460.000	31550.000	90.000	5	VUP	31505.000	Straight
9	33576.000	33666.000	90.000	5	VUP	33621.000	Straight
Package - III							

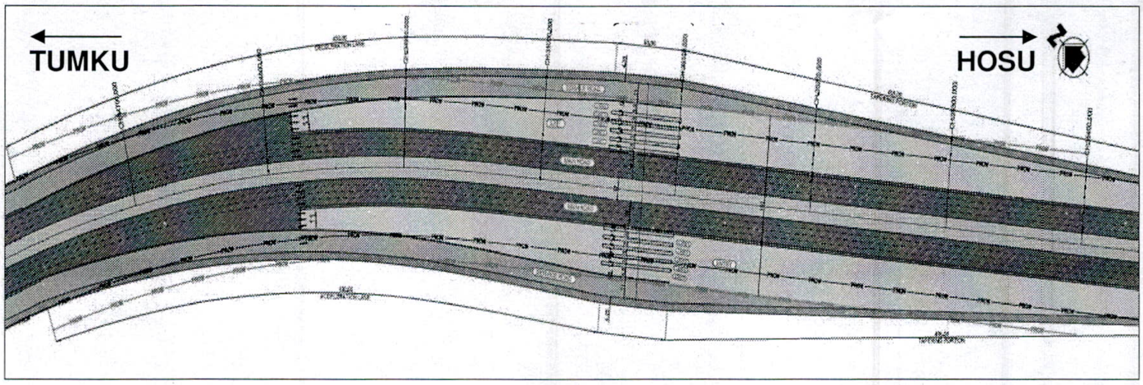


Figure 7-2: Toll Plaza at Intermittent Location

7.4.2 Toll Lane Width

The width of each toll lane is 3.5 m for ETC lanes, 3.2m for other lanes except for the lane for over dimensioned vehicles, where it is be 5.5 m.

7.4.3 Traffic islands at the toll plaza

Between each toll lane of the toll plaza, traffic islands are required to accommodate toll booth. These islands shall be of minimum 25 m length and 2.0 m width. New Jersey Crash barrier will be provided with “bull nose” in front of the median for traffic safety.

7.4.4 Toll booths

Toll booths may be provided of prefabricated materials or of masonry. The toll booths shad have adequate space for seating of toll collector, computer, printer, cash box, etc. It should have provision for light, fan and air-conditioning. Toll booths will be located within toll islands. Toll booth protection in the form of steel frames / GI pipes is provided around the booth.

7.4.5 Canopy

All the toll lanes and toll booths shall be covered with a canopy. The canopy shall be wide enough to provide weather protection to toll operators, drivers and facilities. The canopy shall be of aesthetically pleasing design with cylindrical support columns located at traffic island so that there is no restriction on visibility and traffic movement. Vertical clearance of 8m is proposed considering movement of oversized vehicles.

7.4.6 Toll plaza complex

Toll Plaza administrative building is proposed to be provided adjacent to toll plaza with provision of tunnel from toll booths to administrative building. Administrative building will have facility to provide comfortable office space for manager, cashier and other staff. There will be separate rooms for TV monitors, meetings, visitors, counters to issue passes and smart cards to road users, dormitory, shift change room, toilets etc. The building will also have a strong room for keeping the cash. A garage to accommodate the security van (during operation of loading the collected revenue) will be located adjacent to toll plaza. There shall be parking space in the same campus for vehicles for the staff and workers and other vehicles engaged in the operation of the Project Highway.

7.5 Landscaping and Arboriculture

Aesthetic of areas surrounding the roadways are a prime consideration in the design of roads. This must be in the line with road safety considerations. Landscaping of the environment in the vicinity of roads contributes in a number of ways like:

- Control of soil erosion
- Noise abatement
- Safety barrier
- Glare reduction at night from on coming traffic
- Visual barrier where ever required
- Indicative guide for direction of traffic movement
- Scenic beauty – psychological comfort

Space available within 100m ROW for landscaping and arboriculture for the project road are at:

- Central median of 13m
- Edge space of 75 cm between utility corridor and ROW
- Central space at interchange loops

Arboriculture for the project includes:

- Turfing with sods central median to provide aesthetic look and to prevent soil erosion
- Shrubs all along the central median at ends of median to sufficient height to prevent night glares.
- Turfing with sods between ROW and utility corridor.

7.6 Lighting

Illumination for the project road comprises provision of lighting facilities at following locations:

- All along service road
- Toll Plaza approaches
- Roof of vehicular underpass
- Toll Plaza canopy
- High mast lighting proposed at toll plazas, Rest areas, flyovers and ROB

Illumination level proposed by 40 Lux at all locations and 100 lux for toll roof.

7.7 Footpath

Raised footpath is proposed at edge of service road for pedestrian movement. Footpath is a part of utility corridor with utilities laid below the footpath. Footpath is proposed with interlocking cement concrete paving block of M40 concrete laid over 50mm sand bed. The top surface of footpath will be flush with kerb edge.

7.8 Utility Ducts

Utility ducts are proposed across ROW at every 1 Km interval for taking out utility lines. Ducts with 600mm diameter NP4 pipes are proposed. These ducts will be provided with chamber on both sides of utility corridor.

In addition, BWSSB has sought provision of box type of structure connecting utility corridor for taking water supply lines. These are provided at every 1 Km interval. Size of 2m x 2m is proposed.

SECTION – 8

ITS DEVELOPMENT PLAN

(Details as obtained by DULT in 2015)

8 ITS DEVELOPMENT PLAN – CITY ITS

8.1 Introduction

Karnataka is one of the southern states of India with 38.57 per cent of population living in urban areas. In the last 5 years, the state recorded an increase in urban population of more than 31%. Bengaluru, a capital city of the state, alone accounts for almost 11 per cent of the urban population in the state.

Rapid growth of urban population and economic activities in the city of Bengaluru, coupled with increasing vehicle population, necessitates efficient transport and traffic management. As per the CTTS report published by BMRDA (Bengaluru Metropolitan Development Authority), increasing vehicle population results serious delay of travel, loss of productivity, environment deterioration and increasing road accidents. It is expected that vehicle population in the city will be approximately 17.81 million by 2031. This may result estimated 16.5 million daily vehicle trips in 2031, which will be approximately two times the current traffic volume. Being a hub of major industries such as IT, Automobile, Pharma and Aerospace, urban growth will have immense impact on the economy of the city. With these circumstances, it is necessary to explore ways to mitigate the situation by efficiently utilizing the urban transport and traffic infrastructure to meet the increasing traffic demand.

Intelligent Transport Systems (ITS) have been used in advanced countries to improve performance of the existing infrastructure and transport system for better safety, efficiency, comfort and reducing adverse environmental effects. ITS comprises a wide range of information and communication technologies and is applied in the field of transport to improve road/traffic management and enhance convenience of users, thereby maximizing the existing road capacity.

8.2 City ITS for Bengaluru

ITS for Bengaluru city aims to achieve the following objectives:

- To quantitatively comprehend traffic conditions in the city by collecting real time road traffic data,
- To analyse collected traffic data and generate real time congestion information,
- To analyse collected traffic data for planning evaluation of road and traffic management,
- To provide traffic information to road users in real time,
- To share analysed result with relevant authorities,
- To guide road users to alternate route to destination, and
- To utilise accumulated quantitative traffic data for planning and evaluation of road and traffic measures.

8.3 Necessity of City ITS for Bengaluru

Presently, Bengaluru Traffic Police have a Traffic Management Centre and are monitoring traffic by CCTV. However CCTV does not obtain quantitative data. The quantitative data can be utilised to identify traffic conditions and future planning. VMS are installed at several locations but the displayed information is limited to simple static warning messages. Provision of dynamic traffic information requires quantitative data.

Development of road transport infrastructure is underway such as metro construction, flyover development, etc. However road traffic demand still remains high.

Considering current condition in Bengaluru, the following measures are required.

- To provide dynamic traffic information to users to guide the traffic,
- To utilise quantitative data for planning and evaluation,
- To properly control traffic flow in the city,
- To enhance users' convenience, and
- To shift road traffic demand to public transport.

In order to realise the above measures by ITS, the following ITS components are planned in Bengaluru:

- ✓ Bengaluru Traffic Information Centre (B-TIC)
- ✓ Probe System
- ✓ Vehicle Detector System
- ✓ Automatic Traffic Counter-Cum-Classifier (ATCC) System
- ✓ Closed Circuit Television (CCTV) System
- ✓ Variable Message Sign (VMS) System
- ✓ Internet server/SMS System
- ✓ Advanced Signal System
- ✓ Electronic Road Pricing
- ✓ Common Smart Card

8.4 Bengaluru Traffic Information Centre

Bengaluru Traffic Information Centre (B-TIC) will be established as a central control centre to collect traffic data, analyse the collected data, generate congestion information and analytic result, disseminate to road users and share with relevant authorities with the following objectives (ref Figure 8-1).

- To collect, manage and integrate all data related to road and traffic conditions, incidents, weather condition and other necessary data through roadside equipment, probe vehicle and related agencies,

- To process, store, record and analyse the necessary data for planning and evaluation of road and traffic management, and share with relevant authorities,
- To provide information on traffic to road users in order to take notice of traffic/road conditions to possibly choose to detour away from the congested area or hazardous area,
- To monitor the above collected and processed information on realtime basis, and share the information with planning agencies, road administrators and traffic police,
- To operate the ERP and change the display and monitoring hours when necessary,
- To collect the parking information and display parking availability information in the city, and
- To monitor and manage sub-system components.

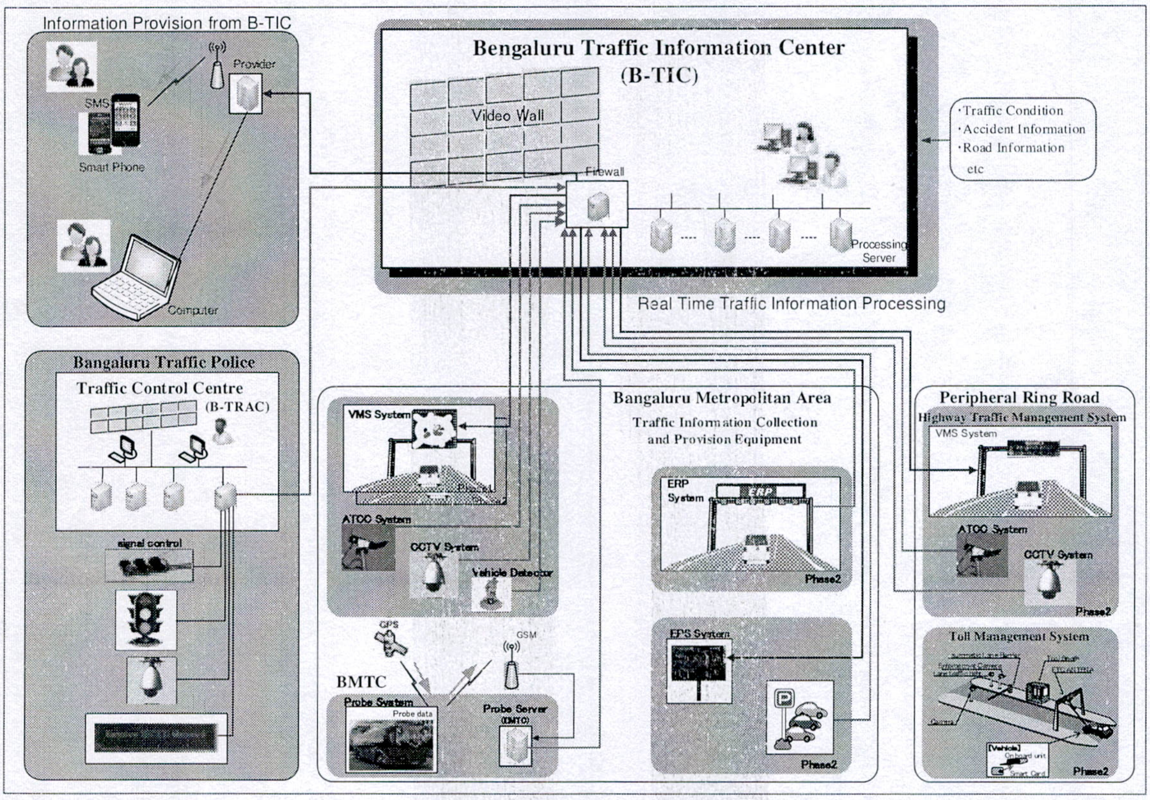

Information Provision from B-TIC
Provider
SMS
Smart Phone
Computer
Bengaluru Traffic Information Center
(B-TIC)
Video Wall
Firewall
Processing Server
·Traffic Condition
·Accident Information
·Road Information
etc
Real Time Traffic Information Processing
Bangaluru Traffic Police
Traffic Control Centre
(B-TRAC)
signal control
VMS System
ATCC System
CCTV System
Vehicle Detector
GPS
GSM
BMTC
Probe System
Probe data
Probe Server
(BMTC)
Bangaluru Metropolitan Area
Traffic Information Collection
and Provision Equipment
ERP
System
ERP
Phase2
EPS System
Phase2
Peripheral Ring Road
Highway Traffic Management System
VMS System
ATCC System
CCTV System
Phase2
Toll Management System
Camera
[Vehicle]
On board unit
Smart Card
Phase2

Figure 8-1: Overall system of the B-TIC and related agencies

8.5 Probe System

8.5.1 Purpose

Probe system collects vehicle tracking information dynamically. A probe device installed in a vehicle consists of Global Positioning System (GPS) unit, processor unit, communication unit and power supply unit.

The probe device periodically sends realtime traffic data such as vehicle position and recorded time to the central system. The probe data collected periodically at the centre is analysed to dynamically generate travel time and travel speed on the road network of digital road map. The analysed data is converted into traffic congestion information and provided to road users. Historical probe data is also used for traffic management and urban development planning. An example of congestion on the road network identified by probe car system is shown in Figure 8-2.

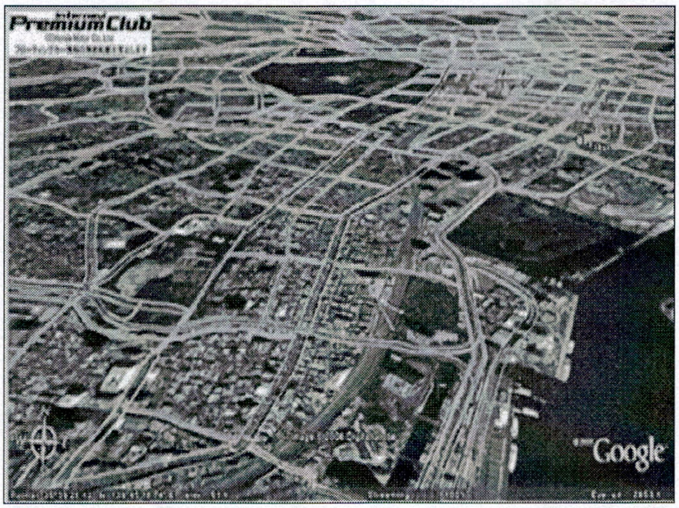


Figure 8-2: Example of Identified Congestion by Probe Car System

8.5.2 Deployment Policy

Currently, Karnataka State Tourism Development Corporation (KSTDC) is using GPS system for tracking their taxis and dispatching them to customers. GPS have been installed on around 500 KSTDC taxis in Bengaluru City.

Bengaluru Metropolitan Transport Corporation (BMTC) has a plan to deploy GPS on 6,700 city buses as part of their Vehicle Tracking and Passenger Information system. The project is currently in progress and is expected to be completed by December, 2014.

B-TIC will use the probe data obtained from KSTDC taxies and BMTC buses. The probe data will be collected by their centres from vehicles, and will be transmitted to B-TIC.

8.6 Queue Length Measurement System

8.6.1 Purpose

A queue length measurement system using vehicle detector will be installed for supplemental purpose for the probe car system.

Probe data provides traffic status of road by sections. However, availability of such data depends on the location of probe cars and there would be no probe car at the section where congestion is frequent. Vehicle detector will be installed upstream of intersection or congestion point. It measures occupancy rate, which is a parameter to judge the congestion level, and determine whether queue has extended to the detector location or not. There are several kinds of vehicle detectors. Amongst them, ultrasonic type is most suitable because of reasonable cost and ease of maintenance compared with other types (ref Figure 8-3).

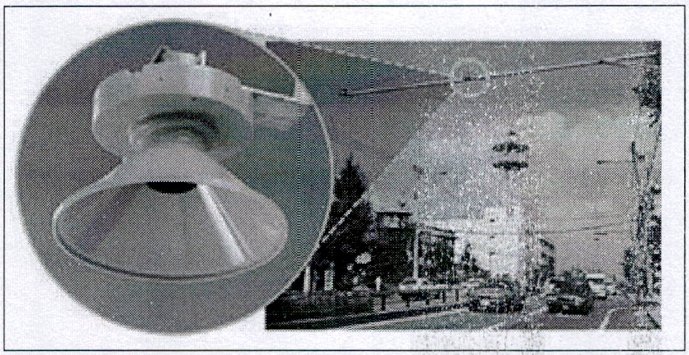


Figure 8-3 Example of Ultrasonic Vehicle Detector

8.6.2 Deployment Policy

Since vehicle detectors judge queue length by vehicle occupancy rate from bottleneck point (normally intersection), they will be installed at several points from the stop line of intersection, normally 300 m, 600 m and 900 m in principle as shown below. Considering condition of road infrastructure in Bengaluru, this principle may not be simply applied at all locations. In such case, adjustment will be made as necessary (ref Figure 8-4).

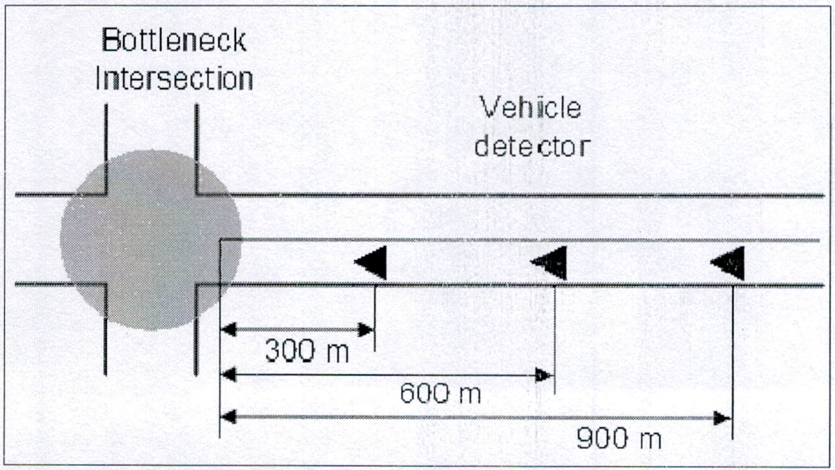


Figure 8-4 Installation Policy of Vehicle Detector

8.7 Automatic Traffic Counter-cum-Classifier (ATCC) System

8.7.1 Purpose

ATCC system will be installed to measure traffic volume classified into large and small sizes. This is for the purpose of utilising the measured data for road and traffic management such as planning/evaluation of new road construction, road widening, etc.

There are mainly four different types of ATCC, namely:

- ultra-sonic type,
- loop-coil type,
- image processing type, and
- infrared type.

Due to absence of lane-keeping discipline and roughness of road surface in Bengaluru, the image processing type will be adopted. The example of image processing is shown in Figure 8-5.

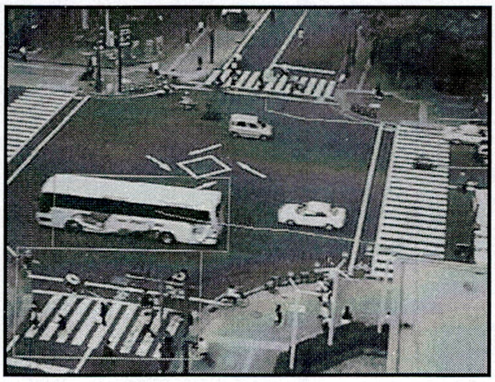


Figure 8-5 Example of Image Processing

8.7.2 Deployment Policy

Installation points of ATCC will be on mid-point between major intersections of trunk roads i.e. National Highway, State Highway, ORR, IRR and other major roads to cover the traffic volume by road section. The location plan is shown in Figure 8-6.

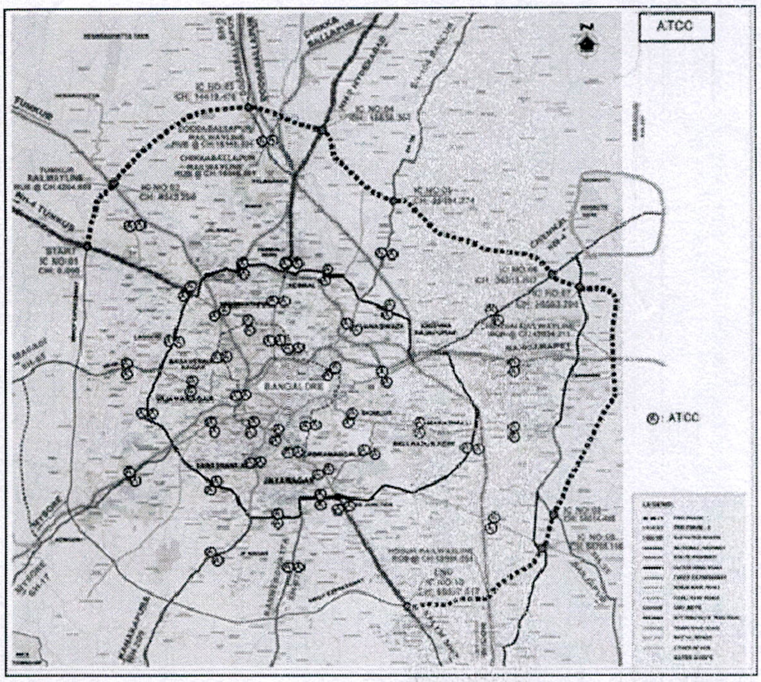


Figure 8-6 Location Plan of ATCC

8.8 CCTV Camera System

8.8.1 Purpose

The purpose of CCTV camera system is to monitor the present traffic, road and weather conditions at accident-prone spots. CCTV camera will have functions of pan, tilt and zooming to capture clear image of vehicles and license plate, if necessary. These captured images will be stored for a certain period and provided to the concerned agencies to develop traffic management measures.

8.8.2 Deployment Policy

CCTV cameras are already installed at intersections in the city and monitored by Traffic Police. Therefore, CCTV cameras will be installed at other accident-prone locations. They are merging points of grade separation and ground level of major roads. In addition to accidents, these locations tend to be a bottleneck of traffic congestion because of merging and diverting activities .

In addition, video link will be prepared between B-TIC and B-TRAC to share moving image of CCTV collected by Traffic Police.

Typical location of CCTV to be installed and location plan are shown in Figure 8-7 and Figure 8-8.

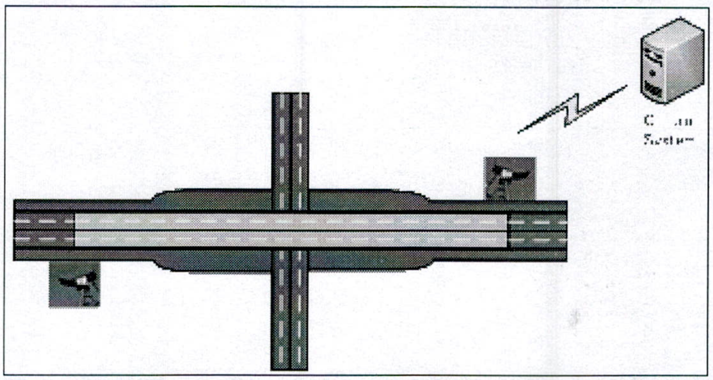


Figure 8-7 Typical Location of CCTV to Be Installed

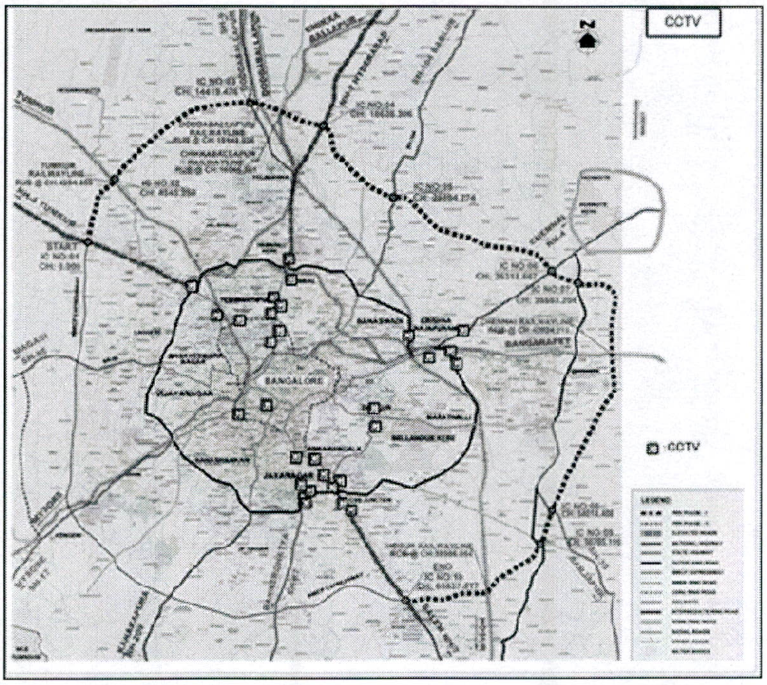


Figure 8-8 Location Plan of CCTV

8.9 Variable Message Sign (VMS) System

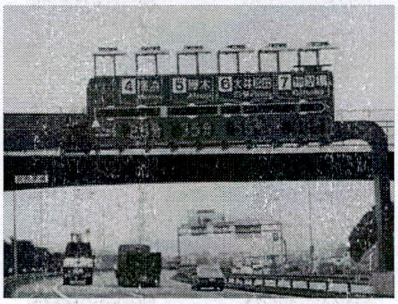
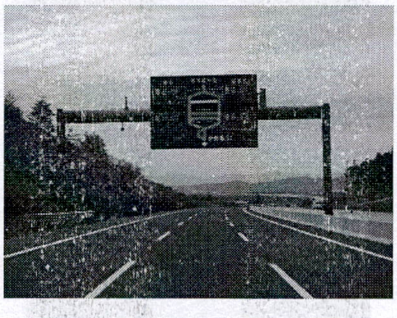
8.9.1 Purpose

The purpose of VMS system is to provide information on road, traffic and weather conditions to drivers on the road. VMS is one of the most effective methods for information provision because the information can be provided to all road users on the road even when the vehicle and driver do not possess devices to access the information such as navigation unit, smart phone, etc.

There are several different types of VMS such as text type, graphic type, etc. The graphic type VMS with multi-display and multi-colour is planned to be installed because it is easier to understand the road/traffic congestion by image without much reading. It is also able to display other information such as incidents and/or time to destination. Thus, drivers can promptly decide whether to take alternative route or not.

Examples of different types of VMS are shown in Table 8-1.

Table 8-1: Various Types of VMS

Type	Image	Function
Text and Symbols		To inform the road, traffic and weather conditions by text and symbols
Travel Time Display		To inform travel time from VMS location to major destinations
Graphic Information Signboard (Multi-colour, multi-display)		To inform about congested sections to allow drivers to select most suitable travel route by using graphic image. Other information such as incidents and/or time to destination can also be displayed.

8.9.2 Deployment Policy

VMS will be installed on radial roads, upstream of major junction of ORR and PRR for vehicles coming into the city so that drivers can recognize traffic/road congestion/condition and choose to avoid the incidents/congestion before entering city centre. Location plan is shown in Figure 8-9.

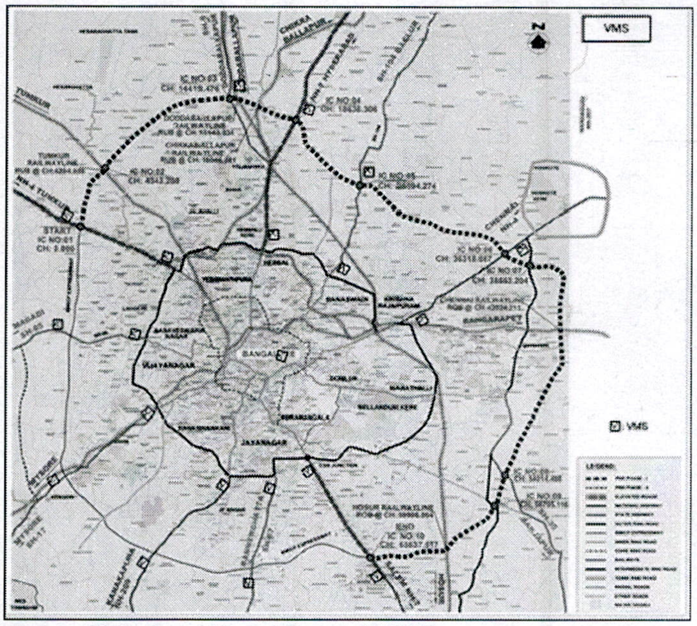


Figure 8-9: Location Plan of VMS

8.10 Advanced Traffic Signal System

Traffic police installed traffic signals at around 336 junctions/intersections in the Bengaluru City. The existing signal system does not have vehicle detector to detect vehicle presence or measures traffic volume, speed or occupancy that indicates prevailing traffic condition. Currently, traffic signal timing is modified according to the time of day, or by the traffic constable at the junction or operator at Traffic Management Centre based on the observation of traffic condition through CCTV camera. The signal system does not have coordination function either and signals operate independently without coordination.

Area traffic signal control system will be upgraded and signal timing will be automatically adjusted based on the prevailing traffic condition gathered by the vehicle detector and in coordination with other signals in the area.

Vehicle detectors are placed at various locations in the road network to collect traffic condition data. Vehicle detector data is sent to the Control Centre for processing and analysis. Based on detector data, optimum signal timing parameter (a combination of cycle, split and offset) is then prepared for each signal. As the signals are controlled from the centre, coordination among the signals are maintained. This type of signal system is shown in Figure 8-10.

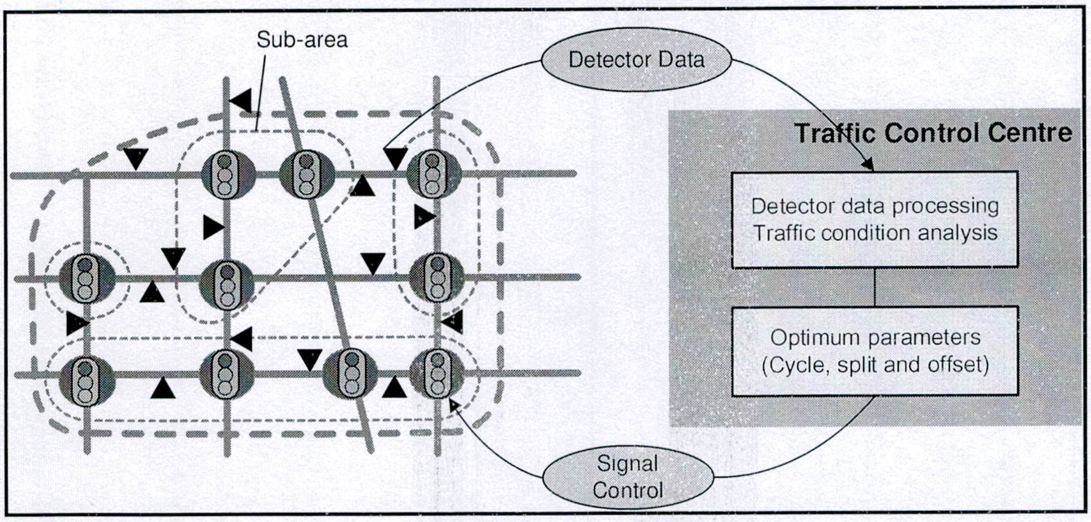

Sub-area
Detector Data
Traffic Control Centre
Detector data processing
Traffic condition analysis
Optimum parameters
(Cycle, split and offset)
Signal
Control

Figure 8-10: New Centre Signal System

System upgrade will be made in three phases. The reason is that the number of signals is too large to implement upgrade at one time. If upgrade work is done at one time, it will take too long and during the work, the system is continuously modified.

In phase 1 project, the control centre system, in particular, software will be modified and new modules such as detector data processing, signal timing calculation and real-time signal control will be added. In addition, 100 signals in the core area of the city (green area in the map below) will be upgraded together with installation of vehicle detector.

In phase 2, the area will be expanded to the Outer Ring Road and another 180 signals (blue area in the figure below) will be upgraded to the new system. In phase 3, signals beyond Outer Ring Road will be upgraded. The area covered by each phase is shown in Figure 8-11.

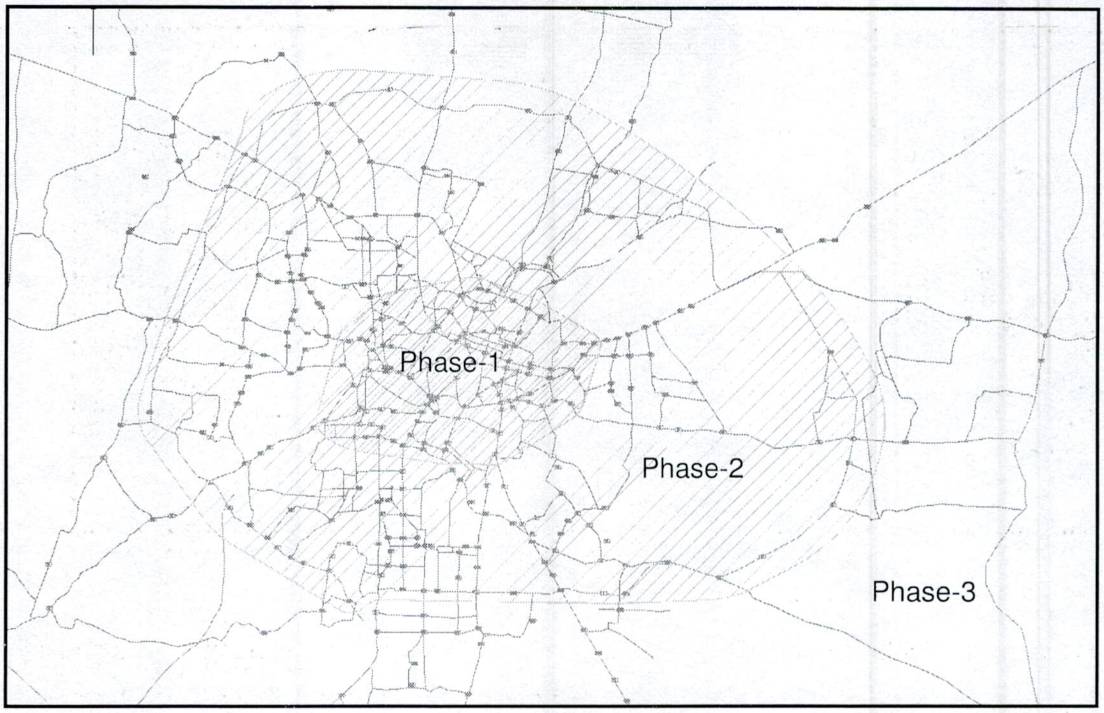


Figure 8-11: System Upgrading in Phase

8.11 Common Smart Card

Nowadays, dissemination of IC (Integrated Circuit) card, also known as smart card, is rapidly increasing and replacing for magnetic card in various fields such as finance, retail, medical, education and transportation because of drastic improvement of convenience by using it.

Smart card is also used as a common mobility card. Because a single smart card makes it easy to travel across different transport such as trains and buses just by touching the card to the reader at the ticket gate or on board buses. Thus the common smart card is increasingly becoming a standard mode of fare payment and retail payments at transport, kiosks and retail shops. The advantages of the common smart card for fare payment are as follows;

- Fast payment processing at entry/exit gate of transportation modes
- Sufficient memory for saving inter-modal travel records
- Flexible payment such as discounts
- Possible to change from zoning or fixed fare collection to distance-based fare collection
- Possible to transfer modes without cash preparation
- Avoiding queue waits for purchasing tickets

Furthermore, it helps transport operators to minimize the leakage of fare collection.

8.11.1 Current Situation of Smart Card & Necessity of Common Card in B'lore

There are two major public transport operators in Bengaluru. They are metro rail and city bus. The metro rail is operated by Bengaluru Metro Rail Corporation Limited (BMRCL).Currently phase I of the metro rail project is under construction and part of it is already in operation. The city bus is operated by Bengaluru Metro Transport Corporation (BMTC). They operate approximately 6,700 buses in the city.

BMRCL has introduced a smart card called "Namma Metro" card for metro rail passengers. BMTC is also planning to introduce smart card for city bus passengers.

In the future, it is expected that a variety of public transport systems, besides metro and bus, such as LRT, BRT and Monorail will be in place in Bengaluru. Further, It is also planned to introduce smart card payment for both Touch & Go and ETC lanes on Peripheral Ring Road.

In such situation, it is necessary to introduce a common smart card which can be used for a variety of services and establish a scheme which allows different players to participate.

8.11.2 Common Card and Clearing House for Bengaluru

The common card and clearing house are planned as follows:

- Introduction of common card for electronic payment for all transport modes, parking, toll collection, congestion pricing, retail shops, etc.
- Establishment of a central clearing house for all transaction clearance and settlement among different cards issuers, transport operators and other related agencies.

The planned central clearing house and relevant services are depicted in Figure 8-12.

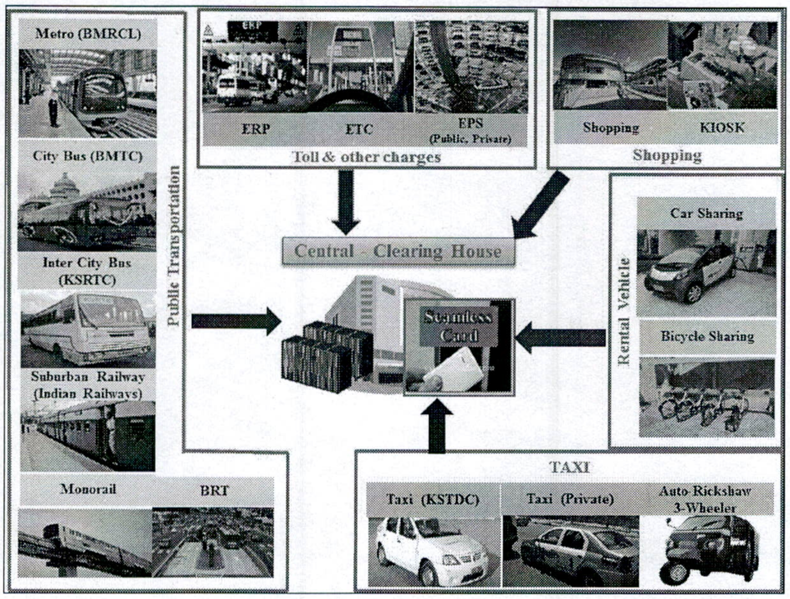

Metro (BMRCL)
City Bus (BMTC)
Inter City Bus (KSRTC)
Suburban Railway (Indian Railways)
Monorail
BRT
Public Transportation
ERP
ETC
EPS (Public, Private)
Toll & other charges
Shopping
KIOSK
Shopping
Central - Clearing House
Seamless Card
Car Sharing
Bicycle Sharing
Rental Vehicle
TAXI
Taxi (KSTDC)
Taxi (Private)
Auto Rickshaw 3-Wheeler

Figure 8-12: Planned Clearing House and Relevant Services

8.12 Congestion Pricing in Bengaluru

Traffic demand management has been implemented in the cities in developed countries to discourage people using congestion routes during peak hours. These measures encourage people to shift from personal vehicles to public transport if they need to travel to congestion areas. Successful examples of road pricing include cities such as London and Singapore.

Development of mass transit and public transport cannot alone sufficiently enhance use of public transport, regulate use of personal vehicles nor reduce congestion on roads. In the case of Delhi, despite extensive metro coverage, number of personal vehicles and congestion levels on road has been on rise. Improvement of public transport and enhancement of its accessibility needs to be coupled with traffic demand management.

Congestion pricing is one of the traffic demand management measures. Introduction of the congestion pricing, using ITS technology which is called 'electronic road pricing (ERP)', is planned in Bengaluru. It will be implemented in a phased manner. Initially, it will be introduced on the congested roads to foster road users' understanding as to effectiveness of ERP. Based on lesson learnt from the initial implementation, further expansion onto area based congestion pricing will be carried out.

8.13 PRR ITS

8.13.1 Introduction

The Peripheral Ring Road (PRR) is a semicircle road surrounding Bengaluru at a distance of 17 km to 25 km from the city centre. It starts at the intersection with National Highway 4

(Tumkur Road) in Madavara located at north-east of the city and ends at Konappana Agrahara connecting with Hosur Road at south-east part of the city passing through northern and eastern parts of the city. NICE road is another semicircle road with which PRR connects at both ends to form a full circle ring road around Bengaluru.

The PRR is a fully access controlled toll road and interchange will be constructed at ten (10) locations including connecting with radial roads, and with NICE also at both ends.

The proposal presented in this section is indicative and will be reviewed by BDA based on overall toll operation and traffic management system with other stake holders, if required.

ITS for PRR is composed of the following two components:

- Toll Management System: TMS
- Highway Traffic Management System: HTMS

8.14 Toll Management System: TMS, Basic Policy

8.14.1 Toll Structure

A closed type toll management system (TMS) will be introduced to the PRR and drivers will be charged with a toll corresponding with the distance travelled. Tolls will be collected from all motorized vehicles using the PRR except special vehicles such as VIP cars, emergency services, military convoys and other exemptions.

8.14.2 Toll Collection Method

Three types of toll collection method will be adopted; Electronic Toll Collection (ETC), Touch and Go (TnG), and manual.

The ETC automatically processes toll collection and allows vehicle to pass without stopping at both entering and exist toll gates. The automatic transaction is realised by communication between antenna installed at toll gate and on-board unit (OBU) equipped inside vehicle. A 2-piece type OBU will be introduced.

The Touch and Go (TnG) deducts toll amount from a contactless smart card when the user touches the card readers installed at toll booth. ETC and TnG will use prepaid payment system and the same contactless IC card (smart card) will be interchangeably used for ETC and TnG.

The ETC equipment will be installed at dedicated lanes for non-stop ETC. Both manual and TnG will be equipped at all other lanes.

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8.14.3 Vehicle classification and toll amount

Vehicles will be classified into at least five (5) types as listed in Table 8-2. The vehicle classifications proposed hereunder make it possible to classify vehicles with suitable type of equipment that measures number of axles and vehicle height. All software, display formats and print-outs will be designed to cater for these five classifications.

Table 8-2: Vehicle Classification for Toll amount

Class	Type
1	Car, Jeep, Van or Light motor vehicle
2	Light commercial vehicle, Light good vehicle, or Mini bus
3	Truck or bus
4	Multi-axle vehicle (3 to 6 axles)
5	Oversized vehicle (7 or more axles)

8.14.4 Cards used with the System

The contactless smart card complying with the ISO/IEC 14443 Type A standard will be used as:

- Ticketing media (Transit Card) for manual collection
- Prepaid card to be used with ETC and Touch & Go; and
- Identity cards for the staff of PRR, toll management system operator and other relevant organizations.

The contactless smart card will have compatibility with the common card which will be introduced for other transport mode in the city and retail shops. Figure 8-13 to Figure 8-16 shows examples of ETC gate, 2-piece type OBU and Touch and Go booth.

Figure 8-13: ETC Gate in Japan

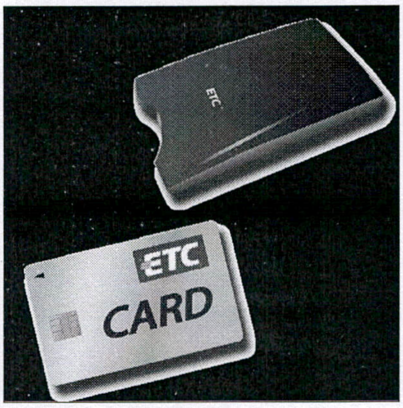

Figure 8-14: 2-piece Type OBU

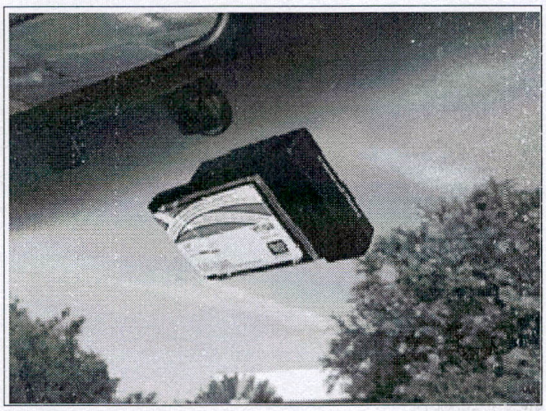

Figure 8-15: Card Inserted OBU fixed on Windscreen

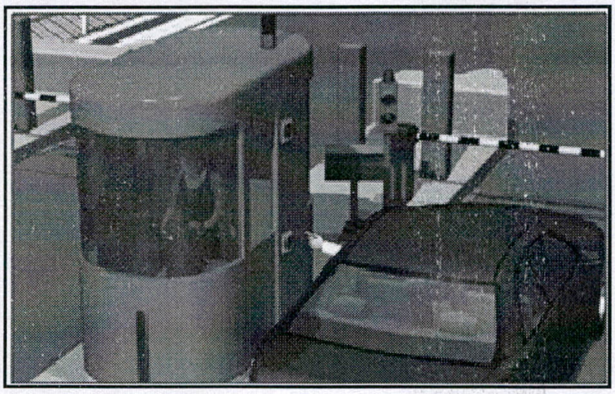

Figure 8-16: Image of Touch and Go Booth

8.15 System Configuration

Toll management system comprises various equipment at three levels. They are toll lane equipment, plaza computer system and toll management centre (TMC) system.

A set of toll lane equipment will be installed in the tollbooth, on the toll island or its vicinity for toll collection operation. The operation of all lane equipment will be monitored continuously by a plaza computer system that will compile; audit and prepare the statistical data for print out, for display in the Plaza building control room or onward transmission to Toll Management Centre (TMC)

A Toll Management Centre (TMC) will be constructed at one of the interchanges along PRR. The centre system will have duplex system configuration with a standby server system that takes over the operation in case of stoppage of main server.

The Plaza Computer System (PCS) will also provide management functions such as attendance recording, reconciliation between declared and expected toll collection and control of cash transferred from the plaza to the bank.

Each plaza will operate as an autonomous system with no real-time data communication between plazas and between plaza and Toll Management Centre (TMC). Thus, interruption of data communication link will cause minimum effect on the continuous toll management system operation. A data communication network via fibre optical cable will be provided. A complete data communication link from the toll lane controller to the PCS and between PCS and TMC system and all the necessary interfaces to this data communication network will be provided.

8.16 Toll Lane Equipment

Various equipment will be installed at toll lane either inside toll booth or on and around island. They are summarized in Table 8-3.

Table 8-3: Various Equipment Proposed to be installed

	Equipment	Purpose
Inside Tollbooth	Toll Lane Controller (TLC)	It controls and monitors all toll lane equipment. It also stores transaction data and other data necessary for toll collection operation.
	Toll Collector Terminal (TCT) without receipt printer (RPR)	It is an interface equipment for toll collector, with display and keyboard. Receipt printer issues receipt.
	Smart card reader/writer (SCRW)	It reads or writes data from or to smart card used as transit card and TnG card.
	Emergency footswitch (FSW)	It initiates an alarm at toll plaza office in case of emergency.

	Equipment	Purpose
	Intercom slave communication unit (ISCU)	It is used as verbal communication unit between toll operator and staff in the toll plaza building.
Toll lane or island	Manual lane barrier (MLB)	It is a barrier for manual lane.
	Overhead traffic light (OHTL)	It indicates whether a toll lane is open or closed.
	Lane traffic light (LTL)	It indicates whether a vehicle stopped at tollbooth is allowed to proceed or not.
	ETC antenna	It communicates with on-board unit (OBU) installed inside vehicle and exchange data for ETC transaction.
	User fare display (UFD)	It indicates amount of toll deducted or balance in the card, and other information as necessary.
	Automatic lane barrier (ALB)	It controls vehicle movement at toll gate, normally stays at closed position and opens when a vehicle is allowed to pass.
	Amber siren beacon (ASB)	It is activated by toll collector and indicates emergency.
	Incident capture camera	It takes an image of vehicle on the toll lane.
	Automatic vehicle classifier system (AVC)	It determines vehicle class based on the physical features of vehicle measured by the system and determines the amount to be charged.

8.17 Plaza Computer System

A plaza computer system (PCS) will be provided in each interchange plaza building control room. The PCS will have two main functions:

- Data acquisition from lane equipment and provision of real time monitoring facilities via visual display unit in the control room of the plaza building.
- Data processing and plaza management via visual display units, printer terminals and data transfer facilities.

The PCS will comprise various inter-linked software modules, some of which will carry out real time functions, such as data communication with lane equipment and provision of detailed monitoring facilities.

8.18 Toll Management Centre System

The TMC system will have the following main functions:

- Data acquisition from PCS.
- Data processing and validation via visual display units, printer terminals, portable memory modules and data/parameter transfer facilities.
- Downloading of operational parameters to PCS.

The TMC system will be connected to PCS by wide area network over optical fibre cable network. The TMC system will make available operating parameters relating to plaza operations for transfer to the PCS and will receive data files from the PCS.

8.19 Software

A set of software will be composed of application for operation of the servers, workstations and computers of lane computer system, Plaza Computer system, Toll Management Centre system and other computers.

The set of the software will consist of those provided by third party and those specifically developed for the project. All third party software will be legally licensed and there will be no restriction on the use in the toll management system.

8.20 Network Equipment

Network equipment will be installed at each interchange toll plaza building to connect plaza computer system with toll lane system and Toll Management System with plaza computer systems.

The network between the Toll Management Centre system and toll plaza system will use the optical fibre cable network along the PRR and a data communication network will be established using Layer 3 Switch.

8.21 Power Supply

Power supply rated at 440V, 3 phases will be made available at the Essential Supply Board of the Interchange Toll Plaza Building. This supply will be backed up by standby generators.

UPS systems will be installed at each interchange location and TMC. All plaza computer system and all lane equipment will be provided power through this UPS to make sure that the power is continuously available to all Toll Management System Equipment during the interruption of commercial power.

8.22 CCTV System

A CCTV system will be introduced as part of toll management system. The CCTV equipment is categorized as two types, CCTV for Toll Systems and CCTV for Security.

The CCTV for toll systems will consist of:

- Toll Booth CCTV Cameras
- Plaza Surveillance CCTV cameras
- Plaza Building Security CCTV cameras

8.23 Highway Traffic Management System: HTMS

8.23.1 Overview

The Highway Traffic Management System (HTMS) is a system that helps the operator of the Peripheral Ring Road (PRR) to safely and efficiently manage the traffic on the PRR. The conceptual system configuration is shown in Figure 8-17. The system consists of three parts of information collection, information processing and surveillance, and information dissemination. In addition, information will be exchanged with other relevant organizations and road users.

Information collection system gathers the traffic, road and weather condition on the PRR through automatic traffic counter-cum-classifier and closed circuit TV (CCTV) installed along the PRR, and through communication systems. The data collected by these devices are sent to the Traffic Control Centre through digital transmission system (ref Figure 8-18).

System operator monitors the conditions of the PRR through the video wall and workstations. Measures are taken in case of incident such as congestion, accident, road or lane closure, and construction work. The conditions of the PRR will be disseminated to PRR users through variable message signs installed on the PRR and also on the roads leading to the PRR, and through Internet. SMS will be sent to the registered users in case of incident. Cooperation with relevant organizations such as Traffic Police, ambulance and wrecker services must be arranged so that coordinated operation can be made in case of incident.

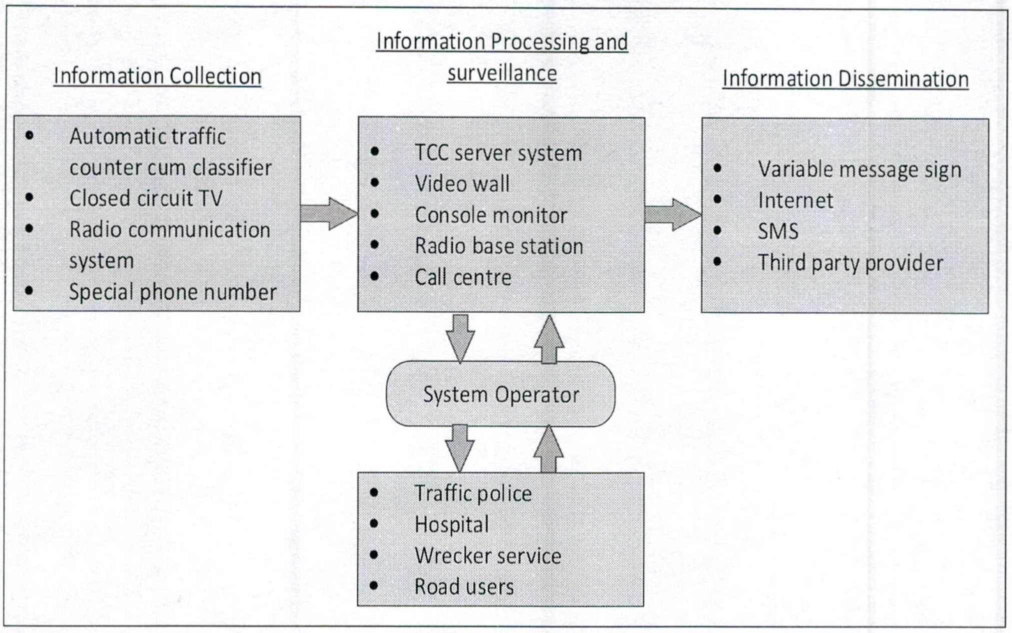
Information Collection
Automatic traffic counter cum classifier
Closed circuit TV
Radio communication system
Special phone number
Information Processing and surveillance
TCC server system
Video wall
Console monitor
Radio base station
Call centre
Information Dissemination
Variable message sign
Internet
SMS
Third party provider
System Operator
Traffic police
Hospital
Wrecker service
Road users

Figure 8-17: Conceptual System Configuration

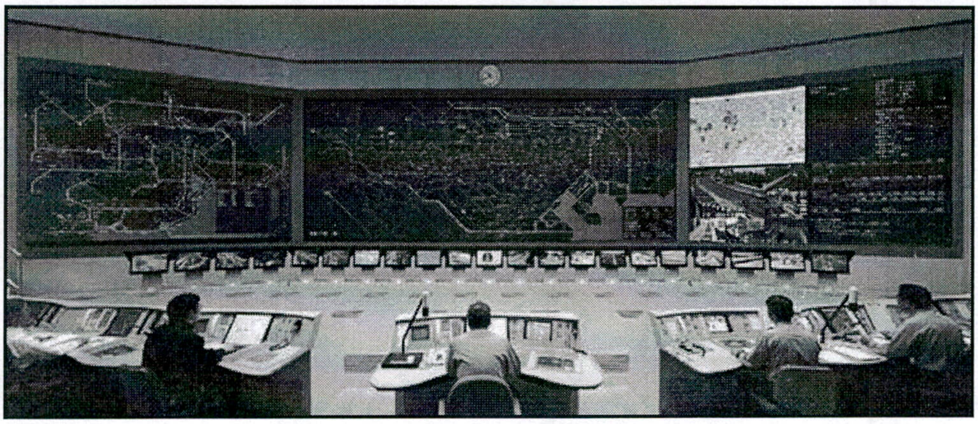

Figure 8-18: Example of Traffic Control Centre

8.24 Outline of the System

In order to ensure safe and comfortable flow of traffic along its entire stretch of Peripheral Ring Road, a Highway Traffic Management System (HTMS) will be introduced. The system will have a Traffic Control Centre (TCC) at one of the interchanges along PRR to oversee traffic control 24 hours a day, 365 days a year. The centre system will have duplex system configuration with a standby server that takes over the main server in case of the stoppage of the latter.

The Highway Traffic Management System (HTMS) collects road and traffic data and provides this data 24 hours a day, 365 days a year to road users, thereby serving as a traffic management system which ensures safe and smooth traffic flow on the PRR. The HTMS system comprises traffic as well as facilities for providing this information. The overall system configuration of the HTMS is shown in the Figure 8-19.

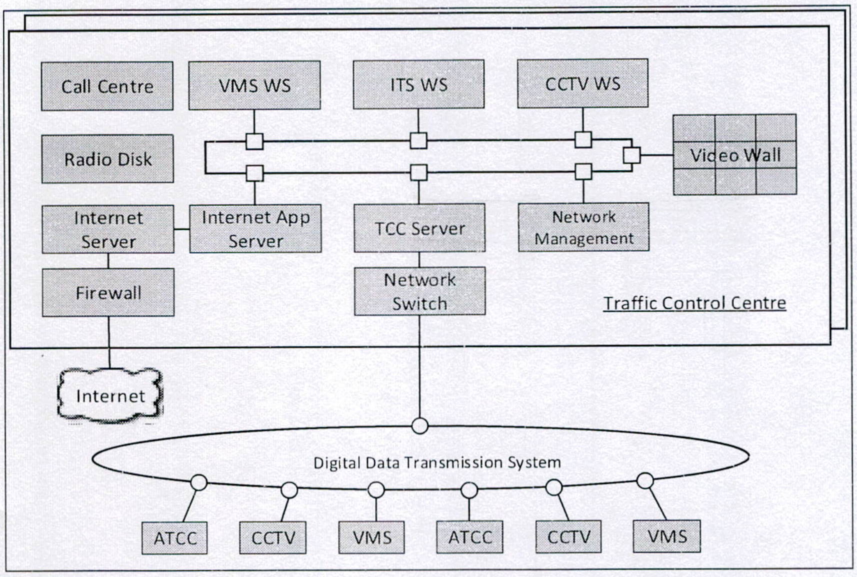
Call Centre
VMS WS
ITS WS
CCTV WS
Radio Disk
Video Wall
Internet Server
Internet App Server
TCC Server
Network Management
Firewall
Network Switch
Traffic Control Centre
Internet
Digital Data Transmission System
ATCC
CCTV
VMS
ATCC
CCTV
VMS

Figure 8-19: Configuration of Highway Traffic Management System

8.25 Features of HTMS

Highway Traffic Management System for the PRR will be designed with the following design concept:

8.25.1 Highly reliable system

As the HTMS plays an important role in the traffic management of the PRR, the system must be highly reliable and operate continuously。Control center provides traffic information 24 hours and 7 days a week.

Data communication system also adopts redundant configuration. Optical fibre cable will be installed on footpaths that are located on both sides of the PRR in ring form so that any interruption of the communication link on one ring can be covered by another ring.

8.25.2 Intensive use of optical fibre cable

The data communication system along the PRR uses optical fibre cable only and no metallic cable will be installed. Optical cable has advantage over metallic cable. It is much lighter and smaller in size so that installation is easier. As it uses light instead of electrical current, it is not susceptible to the lightning and induction caused by high power line. In addition, the optical fibre cable costs less for the same transmission capacity.

8.25.3 Power supply

Various field devices will be deployed along the PRR. All of them require power supply. If power is to be supplied though the power supply cable, its total length will be very large as the cable virtually cover all stretched of the PRR on both side to supply power to VMS, CCTV, and ATCC. However, the interval of every interchange is approximately 5-7 km and toll plaza and tollgate also requires power, since all ITS equipment deployed nearby interchanges, power required for ITS equipment can be supplied from toll plaza buildings.

8.25.4 Use of Video Vehicle Detector

Vehicle detector is the most basic device for a highway traffic management system. It provides vehicle counting data classified into small and large vehicles. Instead of conventional inductive loop vehicle type, which requires maintenance of loop coil embedded in the pavement, video type vehicle detector will be used for ease of maintenance.

8.26 HTMS Components and Functions

8.26.1 Information collection system

The information collection system consists of closed circuit television (CCTV) system and automatic traffic counter cum classifier (ATCC) System. CCTV will be used to monitor the traffic flow. Incident detection function that can detect situational object or object moving reverse direction will be provided to CCTV system (ref Figure 8-20).

Automatic traffic counter cum classifier (ATCC) counts number of vehicles in the sensing area and classifies them into two types, small and large (ref Figure 8-21).

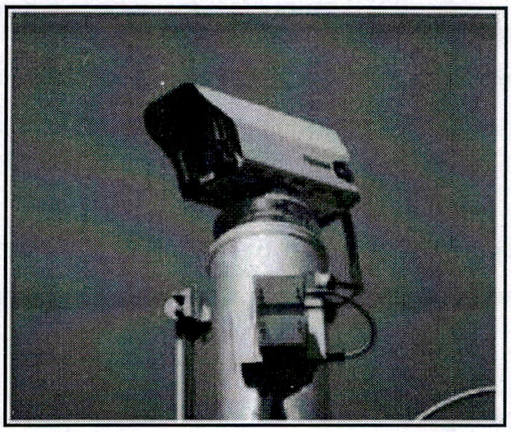

Figure 8-20: CCTV Camera

9.4 Project Cost

The proposed PRR is a green field project. The estimated project civil construction cost is Rs 4869 Crores.

Revenue surveys were completed to substantial portion recently. Assessment of Total cost of land acquisition is in progress.

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9.5 Implementation Plan

The project road of 65 Km is split into 3 sections (ref Table 9-1) so that BDA can take up the construction activity and complete them concurrently. The project road crosses existing National Highways at four locations and hence for the sake of convenience, section break up are drawn at NHs.

Table 9-1: Project Sections for Implementation

Stretch No	Starting	Ending	Length, Km
1	Km 0.000 (Tumkur road)	Km 18.367 (Bellary Road)	18.367
2	Km 18.367 (Bellary Road)	Km 36.323 (Old Madras Road)	17.956
3	Km 36.323 (Old Madras Road)	Km 65.115 (Hosur Road)	28.790

BDA proposes the project to be taken up on Item Rate Contract with Good For Construction Drawings made available to the contractor during construction. The total time frame required for construction of all civil works including toll plaza will be between 30 months – 36 months depending on the section and 18 months is set aside for implementation of Intelligent Transport System (ITS) for the project as a whole. In addition, it is a period of 12 months for implementation of other ITS components is estimated. It is expected that BDA hands over construction land free of encumbrances to an extent that sufficient front is available to contractor. The contractor is expected to carry out required field surveys and investigations, carry out designs and prepare "For Approval" drawings and get it approved by BDA

Item	Car	LCV	Mini Bus	Bus	2-Axle Truck	3-Axle Truck	Multi Axle Truck
Vehicle Price Rs.	4,14,320	6,33,500	8,50,000	10,70,005	11,08,216	12,49,971	14,59,937
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Tyre Price Rs.	2,864	4,482	9,683	9,683	9,082	9,082	9,082
Fuel Per/Lt. Rs.	28	27	27	27	27	27	27
Lubricating Oil (Rs)	84	84	84	84	84	84	84
Maint. Labor (per hr.) Rs.	62	116	127	127	139	136	136
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Interest Rate (%)	12	12	12	12	12	12	12
PCSE	1	1.3	1.3	2	2	2	2.2
Working Hours	1,950	1,500	850	2,200	2,100	2,100	2,100
Annual km	32,000	60,000	34000	1,00,000	75,000	75,000	75,000
Avg. life (Years)	10	8	8	8	8	8	8

- Rise and Fall – 2.5, -1.2 & 0.8 m/Km for 3 sections respectively
- No. of Rise and Falls – 2 / Km for all sections
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- Sub grade CBR – 8%
- Roughness (IRI) – 1.5 m/km (after periodic maintenance in year 2018) for existing roads and 1.5 m/km for new road

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9.6.5 Alternatives

For the project road, following options are considered:

- Without Project / Do-Nothing scenario: No improvement for 6 lane existing road is proposed, only routine and periodic maintenance are considered. Traffic will continue to use existing road network in absence of Peripheral Ring Road.
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    - Reduction in VOC for traffic on new PRR (Bypass alignment)
    - Reduction in VOC on existing roads (ORR and interconnecting radial roads)

9.6.6 Project Cost and Maintenance

For the purpose of carrying out the economic analysis, the cost estimate of the road has been prepared considering road, structures and other amenities and facilities separately. The construction is expected to start in 2019 and be completed in the year 2022, construction period being estimated as 36 months.

The total cost of the improvement has been worked out as Rs 4869 crores at current financial prices (excluding land acquisition) for the total length. The distribution of cost has been estimated as 30% in first year, 45% in second and 25% in third year.

The maintenance works considered for all sections of Existing road and proposed PRR are presented in Table 9-7.

8.25.3 Power supply

Various field devices will be deployed along the PRR. All of them require power supply. If power is to be supplied though the power supply cable, its total length will be very large as the cable virtually cover all stretched of the PRR on both side to supply power to VMS, CCTV, and ATCC. However, the interval of every interchange is approximately 5-7 km and toll plaza and tollgate also requires power, since all ITS equipment deployed nearby interchanges, power required for ITS equipment can be supplied from toll plaza buildings.

8.25.4 Use of Video Vehicle Detector

Vehicle detector is the most basic device for a highway traffic management system. It provides vehicle counting data classified into small and large vehicles. Instead of conventional inductive loop vehicle type, which requires maintenance of loop coil embedded in the pavement, video type vehicle detector will be used for ease of maintenance.

8.26 HTMS Components and Functions

8.26.1 Information collection system

The information collection system consists of closed circuit television (CCTV) system and automatic traffic counter cum classifier (ATCC) System. CCTV will be used to monitor the traffic flow. Incident detection function that can detect situational object or object moving reverse direction will be provided to CCTV system (ref Figure 8-20).

Automatic traffic counter cum classifier (ATCC) counts number of vehicles in the sensing area and classifies them into two types, small and large (ref Figure 8-21).

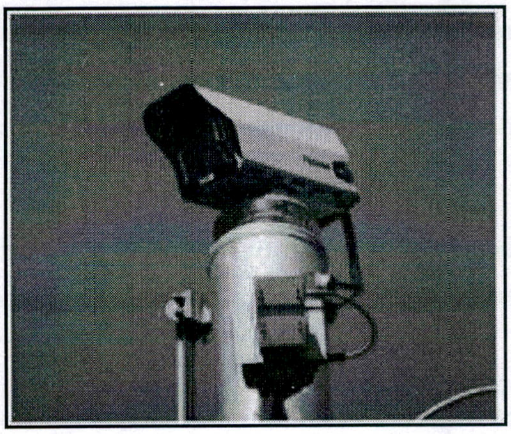

Figure 8-20: CCTV Camera

9 COST ESTIMATE AND IMPLEMENTATION PLAN

9.1 General

Cost estimation is important for the feasibility study as it provides vital input to the economic and financial evaluation of the project. The cost estimates have been prepared for project road in three sections covering all components of works – earthwork, pavement, CD structures, bridges and major structures, road furniture, toll plaza etc. Costs for other items of work which are not directly related to construction, but required for effective project implementation - utility shifting / relocation, designs, surveys, approval, environmental mitigation measures, rehabilitation and resettlement measures are also included.

9.2 Unit Rates

Cost estimates for various items of work are computed using unit rates given in National Highways SR, Bangalore circle 2018-19 for most of the items of work. Unit rates from manufactures / consultants previous experience / KPWD SR for the year 2018-19 are also used for few items of work which are not covered in NH SR. Area weightage of 6% as applicable for Bangalore city is considered.

The Bill of Quantities are worked out based on revised cross section parameters and revised schedule of rates.

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Following items of work are considered in Bill of Quantities and Cost Estimate (NH SR 2018-19):

- Site clearance and Earthwork
- Pavement – flexible and rigid for service road and main road
- Drainage and protective works
- CD structure works
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- Road appurtenances – signage, road markings, crash barrier, delineators, kerbs etc
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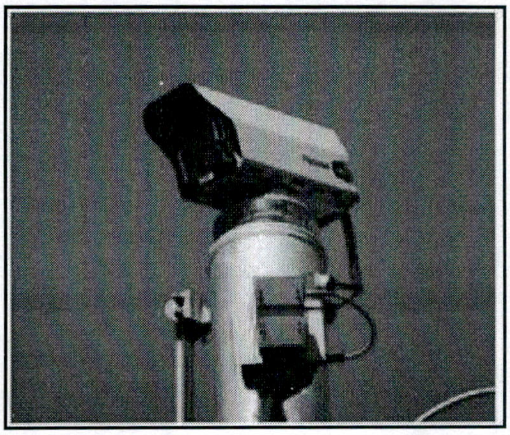

Figure 8-20: CCTV Camera

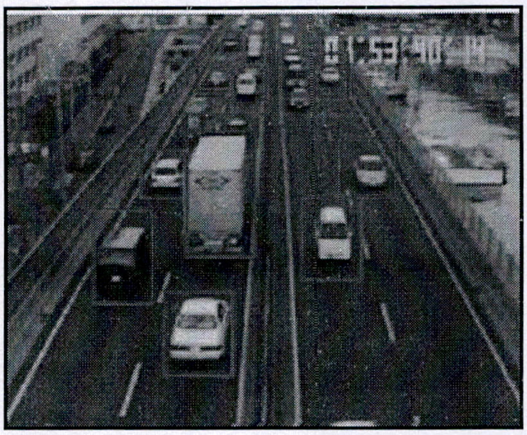

Figure 8-21: Image taken by ATCC

Emergency call box will not be installed on PRR as proliferation of mobile phone made it possible for drivers to contact the Traffic Control Centre or other party. A call centre will be established and special phone number will be assigned to it.

Meteorological data station will not be introduced either, as Bengaluru seldom encounters adverse weather condition that affects driving safety.

Radio communication system will be installed for PRR and possibly for traffic management system. A base station will be constructed at Traffic Control Centre and satellite station or repeater station will be constructed to cover entire stretch of PRR. Necessity and location of satellite station or repeater station will be determined by conducting propagation test. Mobile unit for vehicle and handy walkie-talkie for staff will be used.

8.26.2 Information processing at centre

Traffic flow data collected by ATCC are processed at the Centre into the form suitable for statistical application. During the process, any abnormality, either caused by incidental traffic condition or equipment malfunction, is detected by the processing software and warning is issued for operator's attention.

Image from CCTV camera is normally used for observation by the operator. At the same time, image is recorded by the digital video recorder. In case abnormality is found by the system, a warning is also issued.

All calls to the call centre and conversation over radio communication system will be automatically recorded for reviewing in the future.

8.26.3 Information dissemination

Traffic and other information will be disseminated to the road users through variable message sign. They will be installed at and around interchange. It provides information regarding the road and traffic condition at the downstream section so that drivers can take appropriate action including diverting to detour, or prepared for the incident (ref Figure 8-22).

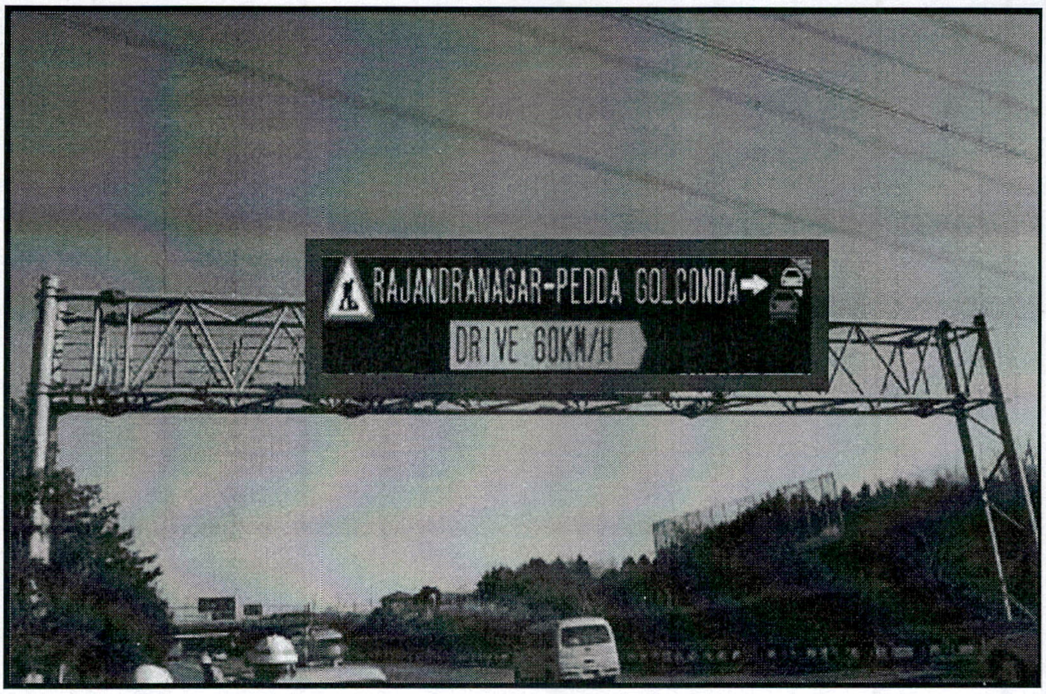

Figure 8-22: Variable Message Sign (simulated image)

Traffic information will also be disseminated through Internet in various formats. Congestion map showing congested locations, incident location or construction site will be prepared for access by the road users (ref Figure 8-23).

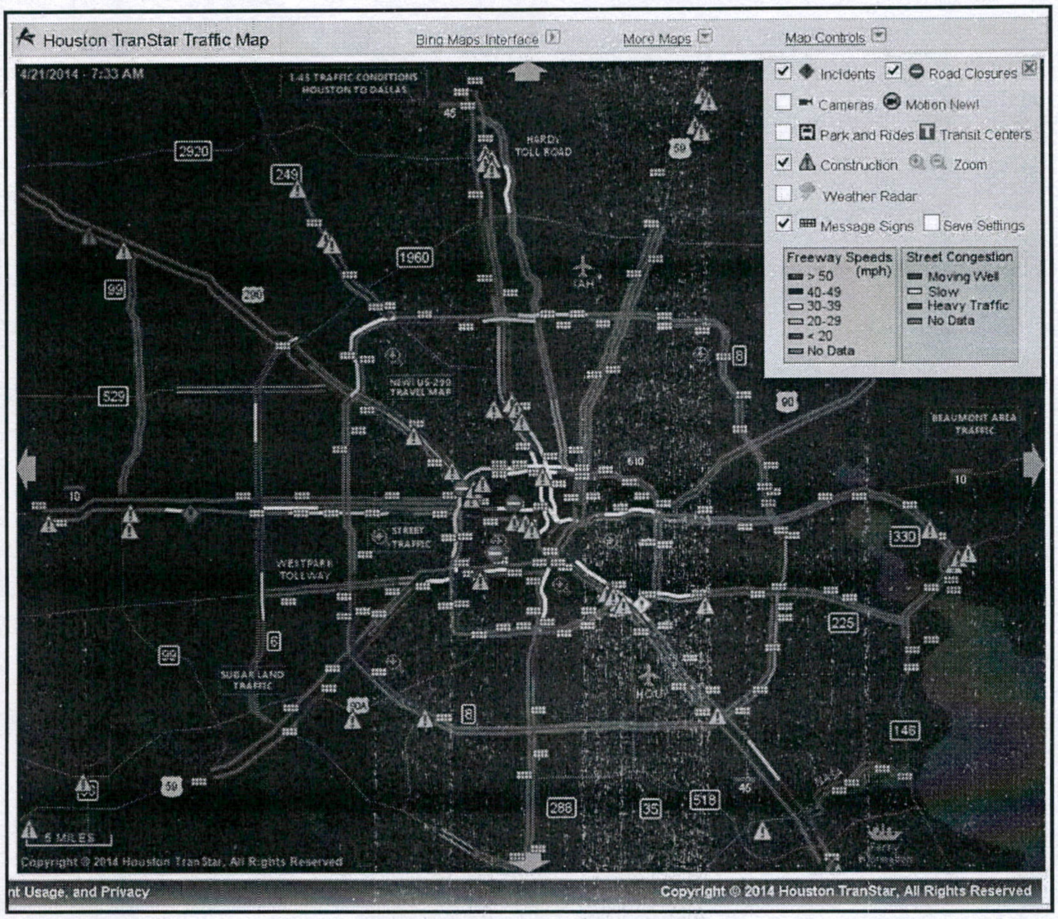
Houston TranStar Traffic Map
Bing Maps Interface
More Maps
Map Controls
4/21/2014 - 7:33 AM
☑ Incidents ☑ Road Closures
☐ Cameras Motion New!
☐ Park and Rides Transit Centers
☑ Construction Zoom
☐ Weather Radar
☑ Message Signs ☐ Save Settings
Freeway Speeds (mph)
> 50
40-49
30-39
20-29
< 20
No Data
Street Congestion
Moving Well
Slow
Heavy Traffic
No Data
HARDY TOLL ROAD
NEW! US-290 TRAVEL MAP
WESTPARK TOLLWAY
SUGAR LAND TRAFFIC
BEAUMONT AREA TRAFFIC
STREET TRAFFIC
IAH
HOU
2920
249
1960
99
529
290
610
10
90
8
330
225
146
288
35
518
59
45
6
5 MILES
Copyright © 2014 Houston TranStar, All Rights Reserved
nt Usage, and Privacy

Figure 8-23: Ex. of Traffic Map (Houston:http://traffic.houstontranstar.org/layers/)

Traffic alert e-mail or SMS will be prepared. When there is incident, construction work, road closure, or other event that hampers normal traffic, e-mail of short message will be sent to the registered subscribers.

8.26.4 Digital Data Transmission System

Roadside equipment installed along the PRR will be connected to the Traffic Control Centre through digital data transmission system using optical fibre cable. Optical fibre cable will be installed along the PRR inside utility ducts to be installed along service road. Branching of fibre cable will be made to extend the cable to the equipment.

The digital transmission system will also be used by toll management system to connect plaza computer system at each interchange with the Traffic Control Centre system.

8.26.5 Power Supply System

Power supply system will be provided to each interchange to supply to the power to the equipment installed at interchange and to the roadside equipment installed near interchange. As no equipment is installed at location at mid-section between interchanges, all equipment for highway management system, toll management system and office use will be supplied by the system.

Each power supply system at interchange will have the capacity suitable for the demand. Generator will be provided to supply power in case of power interruption. Uninterruptible power supply will also be installed to supply stable power to the equipment required to operate without stoppage.

8.27 Facility Deployment Standard

These field devices will be installed at the locations selected based on the facility deployment standard as presented in Table 8-4 to standardize the location. It is noted that locations are adjusted for a short distance to avoid the place which is not suitable for installation such as tunnel and bridges (ref Figure 8-24 and Figure 8-25).

Table 8-4: Facility Deployment Standard

Facility	Location
Variable message sign (VMS)	200 meter upstream of the start of deceleration lane
	200 meter upstream of on-ramp to PRR
Closed Circuit Television (CCTV) camera	Merging and diverting sections at on-ramp of each IC and junction To be installed on the gantry for VMS
Automatic Traffic Counters-cum-classifier (ATCC)	Each Section between ICs.

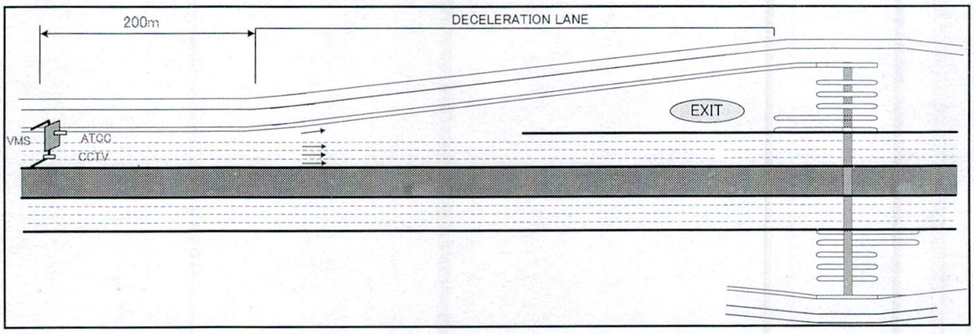

Figure 8-24: Part Plan of VMS Position at Approach to Toll Plaza

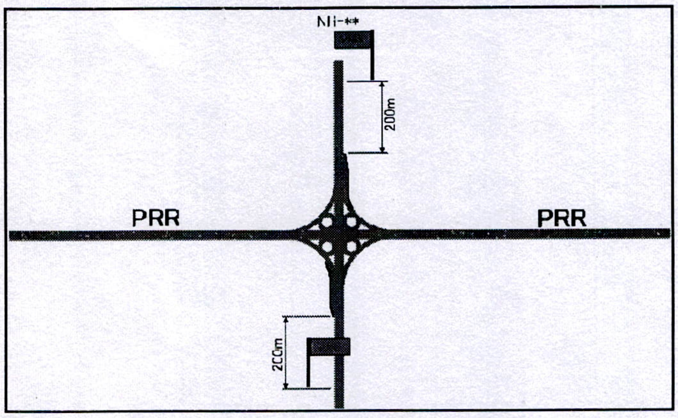

Figure 8-25: Location of VMS at Interchange

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SECTION – 9

COST ESTIMATE AND IMPLEMENTATION PLAN

9 COST ESTIMATE AND IMPLEMENTATION PLAN

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- Toll Plaza works
- Road appurtenances – signage, road markings, crash barrier, delineators, kerbs etc
- Miscellaneous – lighting, landscaping,
- Maintenance – regular and periodic

9.6.4 Assumptions and Inputs

The analysis for the project road is being carried out considering the following assumptions;

- Analysis period is taken as 35 years starting from 2019
- Construction period taken as 3 years for all sections, i.e. 2019–2021 with 30%, 45% and 25% outlay respectively

Traffic composition has been taken same as assigned traffic as per details given in Table 9-4.

Table 9-4: Traffic Proportion of Main Road

Section	Car	LCV	Mini Bus	Bus	2AT	3AT	MAV
Sec-1	73.29%	6.85%	1.47%	3.18%	5.40%	5.07%	4.74%
Sec-2	63.55%	7.67%	2.15%	4.66%	8.77%	7.61%	5.59%
Sec-3	60.42%	6.86%	2.10%	6.42%	9.07%	9.20%	5.93%

- The economic cost for all the items has been assumed as 90% of the financial cost.
- Section-wise financial cost of the project without land acquisition and R&R cost has been presented in Table 9-5.

Table 9-5: Section Wise Financial Cost

Section	Financial cost without Land Acquisition and R&R (Crore Rs)	Length in Km	Financial Cost per Km in Rs.	Economic Cost per Km in Rs.
Section – 1	1514.00	18.367	824304459.1	741874013.2
Section – 2	1228.00	17.956	683893963	615504566.7
Section – 3	2127.00	28.792	738746874.1	664872186.7

- Salvage value considered as 20% of economic cost at the end of analysis period.

Vehicle input values are presented in

- Table 9-6.

Table 9-6: Vehicle Input Values considered at Economic Prices (2019)

Item	Car	LCV	Mini Bus	Bus	2-Axle Truck	3-Axle Truck	Multi Axle Truck

Project road is divided into three homogenous sections between National Highways. Traffic volume counts vary in all these sections. Section-wise traffic is considered in the economic analysis.

9.6.2 Traffic Assignment

The traffic assignment on the proposed road has been carried out based on the traffic volume survey conducted in January 2019. An assessment of section-wise diverted traffic to PRR in the implementation year i.e. 2022 has been made from the above data as shown in Table 9-3.

Table 9-3: Assigned AADT for the Project Road in 2022

Section Details	Car	LCV	Mini Bus	Bus	2AT	3AT	MAV	Daily Total, No
Section-1	22860	2138	459	992	1683	1582	1479	31193
Section-2	19734	2382	667	1448	2724	2362	1736	31053
Section-3	17805	2021	620	1891	2673	2712	1747	29469

Efforts to get the growth rates for various categories of vehicles have been made after analysing the general growth trends in number of registered vehicles, economic indicators of the project region, etc. The traffic growth rates derived by econometric method is compared with growth rates from past traffic data. The final growth rates for diverted traffic adopted in the project are presented in Table 2-31.

9.6.3 Approach to Economic Analysis

The economic analysis of the project road has been carried out through HDM 4-Version 1.3. It allows accessing the physical, functional and economic feasibility of the specified project alternative by comparing against a base case or a 'Without Project/Do Nothing' alternative. The analysis covers the following;

- Life cycle costing of pavement structural performance
- Prediction of road deterioration
- Estimation of road user costs (vehicle operating costs, travel time and accidents)
- Modeling of road works effects and costs associated to the road administration
- Calculation of economic and financial benefits by comparing project alternatives
- Maintenance of existing roads

9.6 Economic Analysis

9.6.1 Introduction

The proposed Peripheral Ring Road (PRR) is planned beyond ORR at a distance of 17km to 25km from city centre. The proposed road is planned for following purposes:

- To take away commercial vehicles and long distance passenger cars from the city.
- Reduce traffic congestion on all existing radial roads leading to existing Outer Ring Road.
- Reduce traffic congestion on existing Outer Ring Road.
- Create a new road network beyond ORR considering future needs for the city.

The proposed will act as an important link for Bangalore city from mobility of view, as present ORR and city roads are congested. The improvement proposal of development of PRR involve certain social costs in terms of utilization of scarce resources and public investment, to have significant benefits flowing to the society. It becomes imperative to undertake an economic analysis to examine whether such projects are significantly beneficial to the society or the economy.

The improvement will bring about a reduction of vehicle operating costs, travel time, accidents, environmental hazards etc. In the present analysis, the benefits are accrued from saving in vehicle operating costs (VOC) and travel time costs for passengers and goods (VOT). The following sections describe the steps followed in the economic analysis using HDM-4, considering inputs from the prevailing ground situation. Section-wise details are shown in Table 9-2.

Table 9-2: Details of Existing & Proposed Road

Section	Project Stretch along PRR	Existing Road Length (km)	Proposed PRR Length (km)	Remarks
Section-1	Km 0.000 (Tumkur road) to Km 18.367 (Bellary	22.612	18.367	1) Existing road is 6 lane 2) Peripheral Ring Road (PRR) is 8-lane with service road
Section-2	Km 18.367 (Bellary Road) to Km 36.323 (Old	29.038	17.956	
Section-3	Km 36.323 (Old Madras Road) to Km 65.115 (Hosur Road)	32.471	28.792	

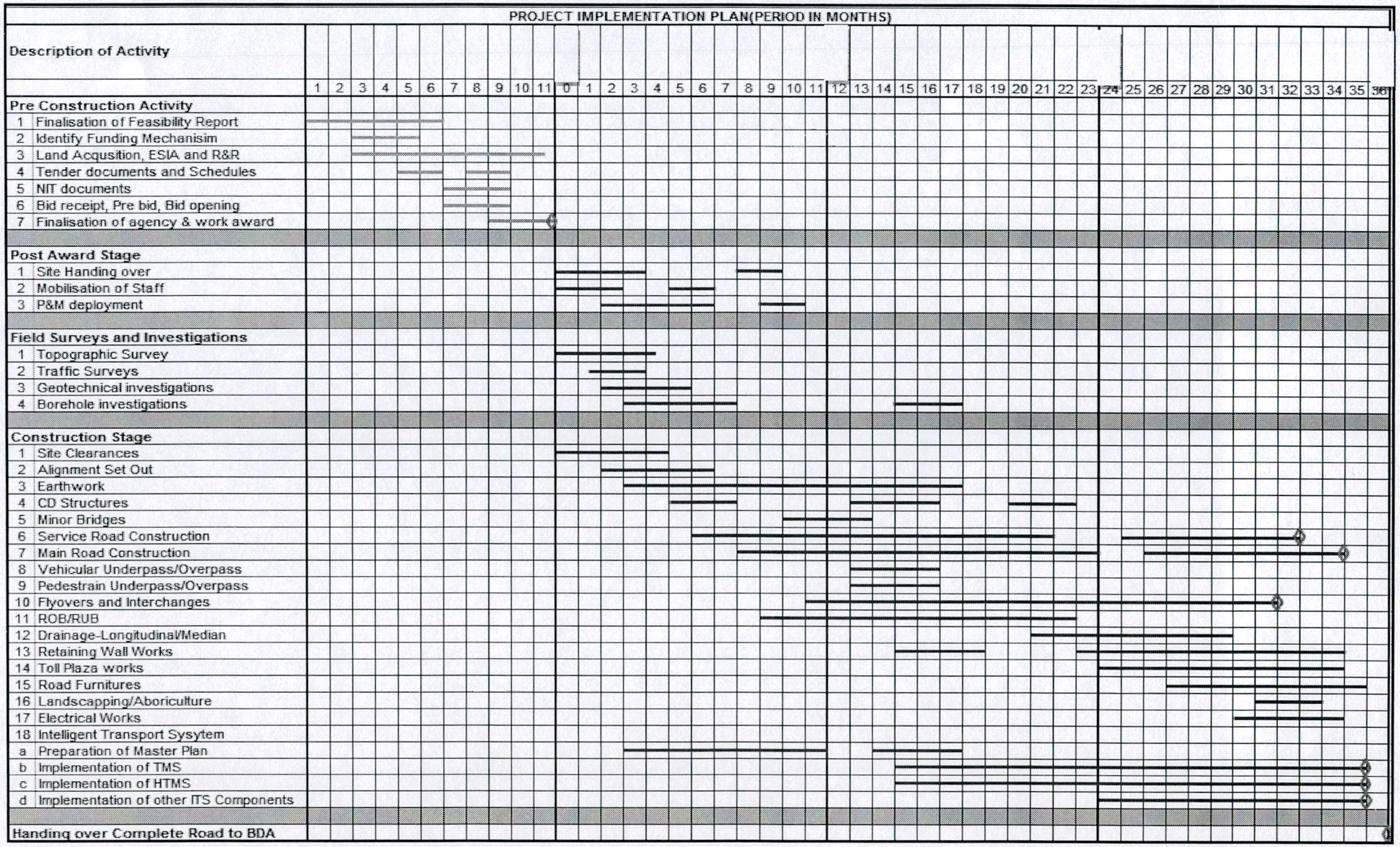

Figure 9-1: Tentative Project Implementation Plan

appointed Independent Engineer and finally issue “Good For Construction” drawings to contractor in line with construction planning and sequence of work.

Tentative project implementation plan is given in Figure 9-1.

9.4 Project Cost

The proposed PRR is a green field project. The estimated project civil construction cost is Rs 4869 Crores.

Revenue surveys were completed to substantial portion recently. Assessment of Total cost of land acquisition is in progress.

The above costs does not cover costs towards implementation of ITS for Bengaluru City and PRR. During recent meeting BDA had with JICA on 22-01-2020, JICA suggested BDA to include ITS towards Bengaluru city to be part of the project and be compatible with PRR project. The technical details and costs towards ITS were provided by DULT in 2015 is Rs 800.00 Cr. The Civil Cost indicated above does not include costs of ITS.

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Avg. life (Years)	10	8	8	8	8	8	8

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9.6.6 Project Cost and Maintenance

For the purpose of carrying out the economic analysis, the cost estimate of the road has been prepared considering road, structures and other amenities and facilities separately. The construction is expected to start in 2019 and be completed in the year 2022, construction period being estimated as 36 months.

The total cost of the improvement has been worked out as Rs 4869 crores at current financial prices (excluding land acquisition) for the total length. The distribution of cost has been estimated as 30% in first year, 45% in second and 25% in third year.

The maintenance works considered for all sections of Existing road and proposed PRR are presented in Table 9-7.

Table 9-7: Maintenance Requirements

Sl No.	Maintenance Work for Existing Road	Maintenance Work for proposed PRR
1	Patching and crack seal as routine maintenance with periodicity of 1 year	Patching and crack seal as routine maintenance with periodicity of 1 year
2	50mm BC overlay as Periodic maintenance at every 6th year	50mm SMA overlay as Periodic maintenance at every 6th year

Though maintenance costs have been used as inputs, the cost stream has been worked out based on the routine maintenance cost of Rs.3.5 lakh/km (in 2011-12) for 4 lane flexible highway as per MORTH circular for analysis and worked out the projected maintenance costs for existing 6 lane and proposed 8 lane configurations in base year 2019.

Periodic maintenance cost of approx. Rs.56 lakh/km for 50mm BC on existing 6 lane road & approx. Rs.63 lakh/km for 50mm SMA on proposed 8 lane PRR are worked out.

Base Year Maintenance costs for existing 6 lane road and 8 lane road are as shown in Table 9-8.

Table 9-8: Maintenance Costs

Maintenance Activity	Without Project (Rs. Lakhs / Km)	With Project (Rs. Lakhs / Km)	
	6 Lane Existing Road	8 Lane PRR	6 Lane Existing Road
Routine Maintenance (every year)	7	10	7
Periodic Maintenance (every 6th year)	84	126	84

9.6.7 Project Benefits

Road user benefits will be from vehicle operating cost (VOC) savings, value of travel time (VOT) saving and saving in maintenance costs. Social benefits will accrue from improvements in quality of life and environment and appreciation of abutting land value, which have not been included in the analysis. Section-wise cost and benefit streams as generated through HDM are shown in Table 9-9, Table 9-10 and Table 9-11 respectively.

Table 9-9: Undiscounted Comparison of Cost Streams for Section-1

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2019	4087.80	0.00	0.00	0.00	-4087.80
2020	6131.70	0.00	0.00	0.00	-6131.70
2021	3406.50	0.00	0.00	0.00	-3406.50
2022	17.59	1495.28	3306.36	4801.64	4784.05
2023	18.05	1680.65	3628.99	5309.64	5291.59
2024	18.52	1445.30	2237.86	3683.16	3664.64
2025	19.01	1252.59	2447.27	3699.87	3680.86
2026	19.50	1358.64	2676.62	4035.25	4015.75
2027	255.62	1534.33	2927.81	4462.15	4206.53
2028	20.53	1753.87	3203.02	4956.89	4936.35
2029	21.07	1935.81	3464.41	5400.23	5379.16
2030	21.62	2071.18	3758.42	5829.60	5807.98
2031	22.18	2000.70	4077.72	6078.42	6056.24
2032	22.76	2182.33	4424.51	6606.84	6584.08
2033	298.38	2476.07	4801.17	7277.23	6978.85
2034	23.97	2625.93	5176.54	7802.47	7778.50
2035	24.59	2785.25	5574.15	8359.39	8334.80
2036	25.24	3005.14	6002.61	9007.75	8982.51
2037	25.90	2785.54	6464.37	9249.90	9224.01
2038	26.57	3151.47	6962.00	10113.47	10086.89
2039	348.30	3268.46	7280.97	10549.43	10201.14
2040	27.98	2176.05	6065.37	8241.43	8213.45
2041	28.71	1044.94	4755.28	5800.22	5771.51
2042	29.46	-156.75	3344.34	3187.59	3158.13
2043	30.23	-1632.40	1825.68	193.28	163.05
2044	31.02	-2849.40	313.33	-2536.07	-2567.08
2045	406.56	-4199.52	-1296.09	-5495.60	-5902.16
2046	32.66	-5504.95	-2866.99	-8371.94	-8404.60
2047	33.51	-5815.38	-3081.36	-8896.74	-8930.25
2048	34.39	-6143.80	-3309.87	-9453.67	-9488.06
2049	35.28	-6484.30	-3533.61	-10017.91	-10053.20
2050	36.21	-6850.39	-3771.01	-10621.40	-10657.61
2051	474.57	-7179.52	-4048.71	-11228.23	-11702.80

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2052	38.12	-7550.27	-4346.48	-11896.74	-11934.86
2053	-2686.08	-7949.58	-4666.36	-12615.94	-9929.86
TOTAL	**13408.02**	**-20286.72**	**63798.31**	**43511.59**	**30103.57**

All costs are expressed in: INR (million)

Table 9-10: Undiscounted Comparison of Cost Streams for Section-2

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2019	3315.60	0.00	0.00	0.00	-3315.60
2020	4973.40	0.00	0.00	0.00	-4973.40
2021	2763.00	0.00	0.00	0.00	-2763.00
2022	17.20	2899.12	4836.04	7735.15	7717.96
2023	17.65	3234.17	5290.92	8525.09	8507.44
2024	18.11	2122.55	2549.22	4671.77	4653.66
2025	18.58	1812.12	2743.98	4556.10	4537.52
2026	19.07	1920.36	2954.30	4874.66	4855.60
2027	249.90	2042.21	3181.50	5223.71	4973.81
2028	20.07	2230.19	3427.02	5657.21	5637.13
2029	20.60	2459.50	3668.55	6128.06	6107.46
2030	21.14	2720.62	3926.77	6647.40	6626.26
2031	21.69	2465.71	4203.85	6669.56	6647.87
2032	22.25	2610.14	4501.21	7111.35	7089.10
2033	291.70	2781.40	4820.38	7601.78	7310.08
2034	23.43	3102.67	5124.67	8227.34	8203.91
2035	24.04	3559.85	5456.09	9015.94	8991.89
2036	24.67	3856.28	5809.57	9665.85	9641.18
2037	25.32	3405.71	6186.65	9592.36	9567.04
2038	25.98	3563.54	6588.93	10152.47	10126.49
2039	340.50	3974.92	6972.27	10947.19	10606.69
2040	27.35	4482.14	7385.90	11868.04	11840.69
2041	28.07	4770.70	7824.58	12595.28	12567.22
2042	28.80	4166.85	6765.76	10932.61	10903.81
2043	29.55	2005.18	3887.97	5893.15	5863.60
2044	30.32	762.85	1053.70	1816.55	1786.23

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2045	397.46	-314.34	-1934.44	-2248.78	-2646.24
2046	31.93	-1817.32	-5105.85	-6923.17	-6955.10
2047	32.76	-3478.36	-8069.98	-11548.34	-11581.10
2048	33.62	-4006.57	-8247.95	-12254.52	-12288.13
2049	34.50	-4624.32	-8420.20	-13044.52	-13079.02
2050	35.40	-4797.99	-8655.80	-13453.79	-13489.19
2051	463.95	-4784.63	-8919.16	-13703.79	-14167.74
2052	37.27	-5153.47	-9205.35	-14358.82	-14396.09
2053	-2172.16	-5749.61	-9516.54	-15266.14	-13093.99
TOTAL	**11292.72**	**32222.16**	**41084.57**	**73306.73**	**62014.01**

All costs are expressed in: INR (million)

Table 9-11: Undiscounted Comparison of Cost Streams for Section-3

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2019	5742.90	0.00	0.00	0.00	-5742.90
2020	8614.35	0.00	0.00	0.00	-8614.35
2021	4785.75	0.00	0.00	0.00	-4785.75
2022	27.58	2152.04	5029.82	7181.86	7154.28
2023	28.30	2419.98	5477.99	7897.97	7869.67
2024	29.03	1551.04	2763.65	4314.69	4285.66
2025	29.79	1288.04	2957.75	4245.79	4215.99
2026	30.57	1363.99	3166.06	4530.05	4499.48
2027	400.71	1503.82	3389.69	4893.51	4492.81
2028	32.19	1721.27	3629.89	5351.16	5318.97
2029	33.03	1873.36	3858.21	5731.57	5698.54
2030	33.89	1985.04	4107.34	6092.38	6058.49
2031	34.78	1704.67	4373.18	6077.85	6043.07
2032	35.69	1865.12	4656.88	6522.00	6486.32
2033	467.74	2164.23	4959.69	7123.92	6656.18
2034	37.57	2248.20	5244.41	7492.60	7455.03
2035	38.55	2315.98	5555.56	7871.54	7832.99
2036	39.56	2447.64	5885.78	8333.42	8293.86
2037	40.59	2208.80	6236.30	8445.10	8404.50

Year	Increase in Road Agency Costs	Decrease in Road User Costs			Net Benefit
		VOC	VOT	Total	
2038	41.65	2549.25	6608.37	9157.62	9115.96
2039	545.99	2689.15	6957.51	9646.66	9100.68
2040	43.86	2926.86	7338.87	10265.73	10221.87
2041	45.00	3075.64	7741.61	10817.25	10772.25
2042	46.18	3233.88	8167.09	11400.97	11354.79
2043	47.39	2953.47	8616.63	11570.10	11522.71
2044	48.62	3431.21	9069.88	12501.09	12452.46
2045	637.32	3501.84	9553.30	13055.14	12417.82
2046	51.20	3690.60	10063.04	13753.64	13702.44
2047	52.53	3921.20	10600.19	14521.39	14468.86
2048	53.90	4172.24	11166.43	15338.67	15284.77
2049	55.31	3643.66	11750.21	15393.87	15338.56
2050	56.76	4145.20	12358.05	16503.25	16446.49
2051	743.94	3979.75	12671.21	16650.96	15907.02
2052	59.76	2336.06	11007.66	13343.72	13283.96
2053	-3767.28	693.47	9239.19	9932.66	13699.94
TOTAL	**19244.70**	**81756.68**	**224201.46**	**305958.14**	**286713.43**

All costs are expressed in: INR (million)

9.6.8 NPV and EIRR

The EIRR and NPV values along with other indicators for the three sections are presented in Table 9-12. It has been observed that the EIRR values for moderate/ heavily trafficked sections (Section–1, Section–2 and Section-3) work out to be 26.93%, 40.50% and 24.87% respectively.

Table 9-12: Section wise EIRR and NPV Values

Sections	Net Present Value (million Rs)	Internal Rate of Return (%)
Section-1: Km 0.000 (Tumkur road) to Km 18.367 (Bellary Road)	**17,578**	**26.93**
Section-2: Km 18.367 (Bellary Road) to Km 36.323 (Old Madras Road)	**28,892**	**40.50**

Sections	Net Present Value (million Rs)	Internal Rate of Return (%)
Section-3: Km 36.323 (Old Madras Road) to Km 65.115 (Hosur Road)	**26,768**	**24.87**

9.6.9 Sensitivity Analysis

The alternatives decided for the analysis will include probable variation in traffic, cost escalation, reduction in benefits etc which are difficult to predict for the future. Hence, sensitivity analysis is carried out considering the following scenarios:

- Case-1 : No variation in cost and no variation in benefits
- Case-2 : 15% increase in cost and no variation in benefits
- Case-3 : No variation in cost and 15% reduction in benefits
- Case-4 : 15% increase in cost and 15% reduction in benefits

Table 9-13: Sensitivity Analysis, Section-wise EIRR

S.No.	Details	EIRR		
		PRR SEC-1	PRR SEC-2	PRR SEC-3
1	Case-1 : No variation in cost and no variation in benefits	26.93%	40.50%	24.87%
2	Case-2 : 15% increase in cost and no variation in benefits	24.15%	36.29%	22.28%
3	Case-3 : No variation in cost and 15% reduction in benefits	23.71%	35.64%	21.89%
4	Case-4 : 15% increase in cost and 15% reduction in benefits	21.16%	31.86%	19.62%

9.6.10 Conclusions

From the economic analysis, it can be inferred that the project IRR (EIRR) is more than **19%** with B/C ratio greater than 1.4, which implies that the project is economically viable.

Construction of new road around Bangalore city will reduce the traffic congestion on existing ORR and radial roads connecting to ORR.

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